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## THESIS

STANDARDIZATION OF HULL, MECHANICAL, AND  
ELECTRICAL EQUIPMENT (H,M&E) INVENTORY

by

John Charles Corbett

September 1987

Thesis Advisor:

David R. Whipple

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Standardization of  
Hull, Mechanical, and Electrical Equipment (H,M&E)  
Inventory

by

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Submitted in partial fulfillment of the  
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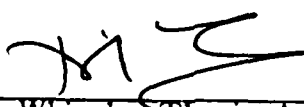
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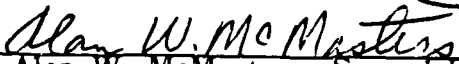
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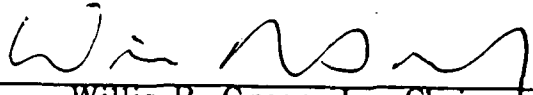
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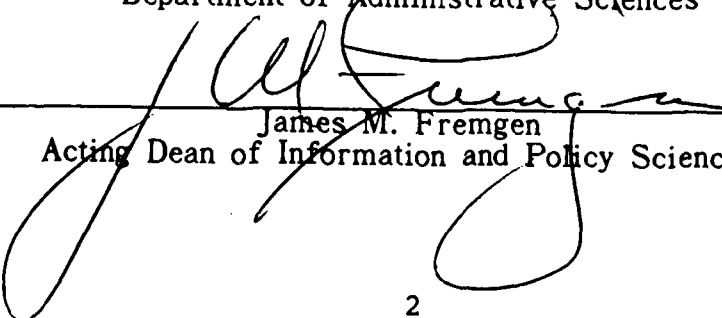
  
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## ABSTRACT

Inventory standardization can increase parts availability while reducing operating costs. Although DOD and Navy policies and guidance support standardization, Navy programs have not been successful in minimizing nonstandard parts in weapon designs. This thesis attempts to identify the supply support problems caused by a lack of inventory standardization and to determine the extent of these problems. A model was developed to estimate the costs resulting from non-standardization of inventory. The model demonstrated that through inventory standardization the Navy could annually save millions of dollars. The savings achieved by reducing nonstandard parts and consolidating items with similar form, fit, and function can be re-invested in inventory to improve depth. Finally, standards offices can make a substantial contribution to the reduction of nonstandard parts if given more authority in the acquisition approval process.

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## **I. INTRODUCTION**

### **A. FOCUS OF THE STUDY**

While expanding to a 600 ship fleet, the Navy is coming under intense pressure to reduce operating expenses. Yet at the same time, it is fulfilling increased commitments. After several years of real growth, the ships are potentially faced with the situation of again "doing more with less". However, the build-up since 1980 has seen the introduction of a greater variety of increasingly complex weapons, and thus, this approach is not as feasible as in previous years. Should political changes erode the support, it may not be possible to maintain some of the new systems. Therefore, alternative methods must be explored to ensure that the weapons are adequately supported and ready when needed. One method of achieving this objective is through inventory standardization. By increasing the depth of a reduced range of parts, the likelihood of the specific part part being available substantially increases.

### **B. OBJECTIVES**

The intent of this thesis is two fold: 1) It will explore the problems caused by a lack of inventory standardization, and 2) It will examine ways that increased use of standard parts can improve availability while reducing costs. It is a broad-based presentation directed towards management level personnel with emphasis on problems and issues. It is not intended to be a detailed step-by-step plan for implementing a standardization program.



During the research it was observed that within the Department of Defense, and especially the Navy, there are "pockets" of knowledge pertaining to standardization. (This includes all facets of the issue, and not just inventory.) Unfortunately, there has not been any attempt to gather the information into one central document. Therefore, an additional underlying goal of this thesis is to provide a basis for such a reference source.

### C. RESEARCH QUESTIONS

In conjunction with the objectives, the primary research question addressed was: How can the Navy improve management of non-standard inventory?

To aid in the research, the following subsidiary questions were addressed:

1. What is the relationship between the acquisition process and standardization of equipment and parts?
2. How has the lack of technical documentation caused inventory ranges to expand?
3. How does Navy policy affect inventory standardization?
4. What are the potential impacts of non-standardization on the Navy's inventory levels?
5. What is being done to implement standardization?
6. What standardization costing models are available as tools in the decision process?
7. What are the costs and impacts of non-standardization?

#### **D. RESEARCH METHODOLOGY**

Research was conducted primarily through literature searches and interviews with Department of Defense (DOD), Navy, and General Accounting Office (GAO) officials. The literature reviewed included Office of Management and Budget (OMB) publications, DOD and Navy instructions and directives, GAO reports, Navy Postgraduate School and Air Force Institute of Technology (AFIT) theses, Naval Audit Service reports, and books. The interviews were conducted both in person and over the telephone. The interviews were with personnel from the Office of the Secretary of Defense, Defense Logistics Agency (DLA), Office of the Secretary of the Navy, Navy Ships Parts Control Center (SPCC), Naval Supply Systems Command, Naval Air Systems, Navy Space and Warfare Command, Naval Sea Systems Command, and Superintendent of Shipbuilding, New Orleans, La.

#### **E. SCOPE OF THE STUDY**

This study limited its scope to Hull, Mechanical, and Electrical (H,M&E) material for two reasons. First, H,M&E parts have a more stable design over an equipment's life than do electronic components. Secondly, H,M&E systems are not as complex as electronic systems and thus data analysis is easier.<sup>1</sup>

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<sup>1</sup> This is not intended to discount the applicability to the electronic field. Rather, lessons learned from H,M&E can be tailored to fit electronic parts.

The thesis examines standardization problems from the perspective of a logistician responsible for supporting operational weapon systems, with the intent of improving fleet material availability.

## **F. LIMITATIONS**

Unfortunately, this study had to be conducted without the assistance of the Navy's Standardization Officer or her office. Repeated efforts to discuss this research were unsuccessful. As a result, we can assume that the observations made in Chapters 3 and 5 concerning the ineffectiveness of NAVSEA's standardization programs are valid.

## **G. ASSUMPTIONS**

Throughout this thesis, it is assumed that the reader is familiar with the federal government's acquisition policies. Furthermore it is also assumed that the reader understands basic Navy, and especially Navy Supply Systems Command, terminology.

## **H. ORGANIZATION**

The thesis is divided into an introduction, two chapters discussing problems and issues, a chapter analyzing costs, and a final chapter of conclusions and recommendations. Chapter II discusses the federal government's and DOD's acquisition policies as they pertain to standardization. Chapter III narrows the focus to the Navy's acquisition and standardization policies. Chapter IV explores three models available for determining the costs for non-standardization, and proposes a fourth model. Chapter V presents the conclusions and recommendations.

Each chapter is designed to answer at least two of the subsidiary research questions. Chapter V is structured to provide a summary of the findings for each of the questions before providing recommendations for resolving the primary question.

## II. BACKGROUND

### A. INTRODUCTION

Standardization is a broad field encompassing design, production, operation, and life-cycle support of a weapon system. Congress in its definition goes so far as to include equipment and ammunition commonalty amongst NATO allies.<sup>2</sup> Potential benefits derived from standardization can be substantial, but if current actions are indicative of managerial desires, then few within the Navy fully comprehend the impact in terms of life-cycle support. This chapter is a synopsis of the topic from the Department of Defense (DOD) perspective. The chapter first defines standardization in terms of life-cycle support. Next it summarizes the acquisition process as it affects standardization, starting with the Office of Management and Budget (OMB) guidance, the Federal Acquisition Regulation (FAR) policy, and DOD directions. After examining DOD programs for controlling part standardization it discusses the process by which a part enters the DOD catalog system. Finally it concludes with an analysis of the problems of duplication resulting jointly from managerial decisions and the Defense Logistics Service Center (DLSC) cataloging process.

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<sup>2</sup> United States Code, Title 10, Chapter 145, Section 2457.

## B. RESEARCH QUESTIONS

This chapter will address the research questions:

1. What is the relationship between the acquisition process and standardization of equipment and parts?
2. How has the lack of technical documentation caused inventory ranges to expand?

## C. DEFINITION

Standardization is

"...the process by which the Department of Defense achieves the closest practicable cooperation among the services and Defense agencies for the most efficient use of research, development and production resources, and agrees to adopt on the broadest possible basis the use of:

- (a) common or comparable operational, administrative and logistical procedures
- (b) common or compatible technical procedures and criteria
- (c) common, compatible, or interchangeable supplies, components, weapons or equipment
- (d) common or compatible tactical doctrine with corresponding organizational compatibility."<sup>3</sup>

The Defense Standardization Manual (DSM), DOD 4120.3-M, states that the objectives of standardization are to:

- "(1) Improve the operational readiness of the Military services.
- (2) Conserve money, manpower, [and] time.
- (3) Optimize the variety of items...used in...logistics support.
- (4) Enhance interchangeability, reliability, and maintainability of military equipment and supplies.
- (5) Ensure that products of requisite quality and minimum essential need are specified and obtained.
- (6) Ensure that specifications and standards are written so as to facilitate tailoring of prescribed requirements to the particular need.

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<sup>3</sup> Department of Defense Dictionary of Military and Associated Terms, The Joint Chiefs of Staff, Washington, D.C., 1979, p 245.

- (7) Assure that specifications and standards imposed in acquisition programs are tailored to reflect only particular needs consistent with mission requirements."<sup>4</sup>

The intent of these objectives, according to the DSM, is to establish and maintain "...a single system of specifications and standards to provide uniform and technically adequate records of the engineering definition of equipment and supplies as a common basis for communication of coordinated defense needs and for contractual agreement in their acquisition."<sup>5</sup>

#### D. LIFE-CYCLE SUPPORT COSTS

Standardization as it has been defined in the DSM can impact the life-cycle support costs of a weapon system more so than any other facet of an acquisition. These costs, termed Operation and Support (O&S) costs, can sometimes accrue for more than 20 years following procurement of the final piece of hardware. LCDR Porter divides O&S expenses into initial non-recurring costs (such as provisioning and documentation), and the recurring costs of personnel, material, and overhead.<sup>6</sup> He notes that "...funds required in supporting a system are often twice those spent in acquiring it..." and concludes that downstream costs are substantial.<sup>7</sup>

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<sup>4</sup> DOD 4120.3-M, Defense Standardization Manual, September 11, 1985, para 1-103.1 a.

<sup>5</sup> DOD 4120.3-M para 1-103.1 b.

<sup>6</sup> LCDR David L. Porter, USN, Controlling Life-Cycle Cost: A Management Perspective, Thesis, Naval Postgraduate School, Monterey, California, December 1985, p 20.

<sup>7</sup> Margaret A. Emmelhainz, "Innovative Contractual Approaches to Controlling Life-Cycle Costs," Defense Management Journal, Second Quarter, 1983.

Thus it is apparent that O&S costs can significantly impact a system's cost-effectiveness.

These O&S costs are comprised of:

- (a) Provisioning and Technical Documentation and efforts related to provisioning
- (b) Maintenance
- (c) Training
- (d) Technical Manuals
- (e) Installation
- (f) Configuration Control
- (g) Testing (system as well as parts)
- (h) Inventory acquisition, replenishment, management, holding, and ordering<sup>8</sup>

Standardization can reduce these O&S costs by:

- "(1) Reduc[ing] inventory costs for spare parts since standardization infers increased depth and decreased equipment ranges.
- (2) Reduc[ing] provisioning, inventory management, storage, transportation and handling and training costs.
- (3) Reduc[ing] volume and associated costs for equipment configuration control, ship drawing banks, technical manuals, and maintenance plans.
- (4) Improving planning for upkeeps, restricted availabilities and overhauls. More sophisticated material requirements planning programs can be used when all the ships have the same equipment baseline."<sup>9</sup>

LCDR Olson points out that "...the overall result is an improved fleet readiness through increased reliability and supportability."<sup>10</sup>

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<sup>8</sup> LCDR James P. Poe, SC, USN, The Management of Competitively Procured Stock Numbers, Paper presented to American Society of Naval Engineers Conference, March 25, 1987.

<sup>9</sup> LCDR Stephen J. Olson, SC, USN, Standardization and Competition as Applicable to New Construction Shipbuilding Programs, Unpublished paper, Naval Postgraduate School, Monterey, CA, March 1987, p 3-4.

<sup>10</sup> Olson, p 3-4.



## E. FEDERAL ACQUISITION PROCESS

The Office of Management and Budget (OMB) Circular A-109 provides the structure for system acquisition. During design, the process must not "...conform mission needs or program objectives to any known systems or products that might foreclose consideration of alternatives."<sup>11</sup> This statement is telling the Project Manager (PM) that the mission's needs should not be adjusted to fit available equipment thereby excluding alternative systems. It implies that it is acceptable at that stage of a project to ignore standardization for the sake of new technology.

A-109 also requires the agency to provide the contractor with the life cycle cost factors for use "...in the evaluation and selection of the system for full-scale development and production."<sup>12</sup> "Selection of a system(s) and contractor(s) for full-scale development and production is to be made on the basis of (1) system performance against current mission need and program objectives, [and] (2) an evaluation of estimate acquisition and ownership costs..."<sup>13</sup> Despite the requirements, the Circular does not define the elements for measuring life-cycle costs.

The Federal Acquisition Regulation (FAR) states that the agency head is responsible for "...reviewing and approving acquisition plans...[and]...establishing criteria and thresholds at which ... life-cycle-

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<sup>11</sup> OMB Circular A-109, Major System Acquisitions dated April 5, 1976, p 8.

<sup>12</sup> OMB A-109, p 9.

<sup>13</sup> OMB A-109, p 10.

cost techniques will be used."<sup>14</sup> This requirement in essence stipulates that life-cycle costing procedures must be developed for use by all activities within the agency.

The acquisition strategy addresses all facets of the procurement including "...the technical, business, management, and other significant considerations that will control the acquisition."<sup>15</sup> Within the plan the manager shall "...discuss how life-cycle cost will be considered...[and]...if appropriate, discuss the cost model used to develop life-cycle-cost estimates."<sup>16</sup> However, the FAR does not specify the level of detail that the PM must provide.

The acquisition plan must also address the logistic impacts by describing "...the assumptions determining contractor or agency support...over the life of the acquisition, ...the reliability, maintainability, and quality assurance requirements,...the requirements for contractor data (including repurchase data) and data rights, their estimated cost, and the use to be made of the data,...standardization concepts, including the necessity to designate, in accordance with agency procedures, technical equipment as 'standard' so that future purchases of the equipment can be made from the same manufacturing source."<sup>17</sup>

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<sup>14</sup> Federal Acquisition Regulation (FAR), February 3, 1986, para 7.103 (g)-(h).

<sup>15</sup> FAR para 7.105.

<sup>16</sup> FAR para 7.105 (a)(3)(i).

<sup>17</sup> FAR para 7.105 (b)(12)(i)-(iv).

In system development solicitations the FAR requires PM's to consider items, in the design, that are already in the federal supply system or "...which the Government will be able to acquire competitively in the future if they are likely to be needed in substantial quantities during the system's service life"<sup>18</sup> Additionally, in a system production contract the PM "...shall consider requiring offerers to include...proposals [providing] opportunities [for] ...the Government...to obtain, on a competitive basis, items acquired in substantial quantities during the service life of the system."<sup>19</sup> The proposals should include provisions "...to provide the Government the right to use technical data [developed during] the contract for competitive future acquisitions, together with the cost to the Government... of acquiring such technical data."<sup>20</sup>

The FAR stipulates the use of full and open competition as the primary means of acquisition and, to this end, discourages any requirement that would preclude it. Specifications and descriptions must be minimized and may be stated in terms of function, performance, or design requirements. The FAR requires the agency to use function or performance when practicable, rather than design, in order to stimulate competition.<sup>21</sup> "...Plans, drawings, specifications, standards, or purchase descriptions shall state only the Government's actual minimum needs and

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<sup>18</sup> FAR para 7.106 (a)(2).

<sup>19</sup> FAR para 7.106 (b).

<sup>20</sup> FAR para 7.106 (b)(1).

<sup>21</sup> FAR para 10.002.

describe the supplies and/or services in a manner designed to promote full and open competition."<sup>22</sup>

## F. DEPARTMENT OF DEFENSE POLICIES

Defense acquisitions are governed by DOD Directive 5000.1, Major System Acquisitions, and DOD Instruction 5000.2, Major System Acquisition Procedures. 5000.1 clearly states that "...a cost-effective balance must be achieved among...production and ownership costs...and system effectiveness..."<sup>23</sup> While DODI 4120.3 states that "...the degree and effectiveness of standardization efforts will be an issue to be addressed during DSARC and (S)SARC milestone reviews..."<sup>24</sup>, the PM, following 5000.2 direction, is only required to submit a one line summary of the total life-cycle costs.<sup>25</sup> The PM, therefore, has the opportunity to make the life-cycle costs fit any budget number that will sell the system. Mr. Perkins concurs and notes that the Acquisition Strategy calls for supporting detail but, by the time an acquisition reaches the DSARC levels, the senior officials are only concerned with system feasibility.<sup>26</sup>

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<sup>22</sup> FAR para 10.004 (a)(1).

<sup>23</sup> DOD Directive 5000.1, Major System Acquisitions, March 12, 1986, para C.2.d.

<sup>24</sup> DOD Instruction 4120.3, Defense Standardization and Specification, February, 10, 1979, para E.2.

<sup>25</sup> DOD Instruction 5000.2, Major System Acquisition Procedures, March 12, 1986, enclosure 1. The summary includes all internal project operating costs along with equipment support costs.

<sup>26</sup> Interview with Mr. David Perkins, Command Standardization Officer, Space and Warfare Command, June 12-17, 1987.

DoD Directive 5000.39, Acquisition and Management of Integrated Logistic Support for Systems and Equipment, provides life-cycle management policy for systems as well as equipment. It states that, "...The primary objective of the ILS program shall be to achieve system readiness objectives at an affordable life-cycle cost. Early ILS program activity shall focus on designing desirable support characteristics into systems and on determining support requirements. Subsequent activity shall focus on acquisition, evaluation, and deployment of support resources."<sup>27</sup> The directive recommends consideration of explicit and visible plans for standard parts and components as a part of Milestone II, but does not require submission of the plans.<sup>28</sup> While the DSARC process attempts to balance program needs with life-cycle support costs, technical requirements can potentially override follow-on support considerations.

#### G. STANDARDIZATION PROGRAMS

The Defense Standardization and Specification Program (DSSP) was established in response to the Defense Cataloging and Standardization Act.<sup>29</sup> Its goal is to "...improve the operational readiness of the DOD Components and assure the cost-effective mission performance of systems

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<sup>27</sup> DoD Directive 5000.39, Acquisition and Management of Integrated Logistic Support for Systems and Equipment, November 17, 1983, para E.I.

<sup>28</sup> DOD Directive 5000.39, enclosure 1, para 3.M.(8).

<sup>29</sup> The original law was enacted on July 1, 1952 as Public Law 82-436, updated by P.L. 84-1028 on August 10, 1956, and codified as USC Title 10, 2451-57 in 1982. DOD Manual 4120.3-M, Defense Standardization Manual, September 11, 1985.

and equipment by fostering the efficient use of resources and optimum reuse of the products of engineering efforts."<sup>30</sup>

The DSSP is administered by the Defense Material Specification and Standards Office (DMSSO). It is responsible for managing all facets of standardization, of which parts and data are just a subset, and identifying areas where benefits can accrue as a result of the program.

DSSP receives Congressional attention. Annually, on January 31, DMSSO is required to submit an accomplishment report to Congress that contains:

- "(1) the number of separate specifications that have been consolidated into single specifications for use throughout the Department of Defense;
- (2) the reduction in the number of sizes or kinds of items that are generally similar; [and]
- (3) any other information that the Secretary considers will best inform Congress of the progress of the standardization program."<sup>31</sup>

The report includes standardization of systems, equipment, and parts as well as programs of interest to Congress such as Acquisition Streamlining, Soldering Standardization, and Acquisition and Distribution of Commercial Products.<sup>32</sup>

The individual services are also required to establish an office similar in function to DMSSO. The Departmental Standardization Officer

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<sup>30</sup> DOD Directive 4120.3, Defense Standardization and Specification, February, 10, 1979, para C.

<sup>31</sup> USC Title 10 Chapter 145 Section 2455 (b).

<sup>32</sup> Defense Material Specification and Standards Office, Defense Standardization and Specification Program (DSSP), Fifty-Sixth Report to Congress, January 1986.

(DepSO) supports the unique requirements of the service in addition to implementing DMSSO policies. When DMSSO assigns a project, the DepSO for the lead service is the focal point for the other departments.<sup>33</sup>

The DSSP requires that PM's use existing designs and products when practicable. It states that standardization must be an essential consideration in acquisition decisions and that the PM must minimize the number of new items introduced into the supply system. Furthermore, it dictates that, when cost-effective, standard parts must be used during full scale engineering development, production, and deployment. To this end, the DSSP requires application of the DOD Parts Control Program in system acquisitions.<sup>34</sup>

The DOD Parts Control Program (DOD PCP) "...promotes the use of standard parts in the design of defense systems."<sup>35</sup> The goal of the DOD PCP is:

- "(a) To conserve resources and reduce life-cycle cost by reducing the varieties of component parts.
- (b) To promote the application of established standard parts, or parts with multiple application, of known performance during the design, development, production, or modification of equipment and weapons systems.
- (c) To apply engineering techniques that may assist system or equipment acquisition managers and their counterparts to identify and select established standard parts or parts with multiple application to enhance inter- or intra- departmental

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<sup>33</sup> Within the Navy, the Hardware Systems Commands (HSC) each have a Command Standardization Officer (ComSO) performing a similar role for their command.

<sup>34</sup> DOD Instruction 4120.3, para E.

<sup>35</sup> DOD Instruction 4120.19, DoD Parts Control Program, October 30, 1985, para C.

- systems commonalty, interchangeability, reliability, maintainability, standardization, and interoperability.
- (d) To standardize piece parts, potentially reducing prices through greater demand for standard parts; to reduce in varieties of parts in the inventory; to increase production runs; to enhance competition among multiple sources; and to reduce replenishment Procurement Acquisition Lead Time (PALT)."<sup>36</sup>

The DOD PCP Instruction delineates the responsibilities of the Military Parts Control Advisory Groups (MPCAG). MPCAG's are established at each of the DLA Stock Points. They review equipment drawings during the design phase to evaluate contractor claims of part uniqueness and therefore not stocked in the system. The MPCAG attempts to identify items within the system that have the same form, fit, and function. If the MPCAG does identify a duplicate the contractor is required to use that part unless he can demonstrate that the new part has a unique feature that cannot be satisfied with current inventory.

MIL-STD-965A "...implements the guidelines and requirements established by DODI 4120.19...and is applicable to new design and modification of existing design."<sup>37</sup> It notes that "...In research, exploratory development and advanced development where the design of prototype hardware is not involved, the use of standard parts is advocated, but is secondary to the prime objectives of the development."<sup>38</sup>

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<sup>36</sup> DOD Instruction 4120.19, para E.2.

<sup>37</sup> MIL-STD-965A, Military Standard-Parts Control Program, 13 December 1985, p iii.

<sup>38</sup> MIL-STD-965A, p iii.



When parts are required, the PM must invoke MIL-STD-965A in all contracts to force the contractor to use standard parts whenever possible. MIL-STD-965A states that it is the contractor's responsibility to:

- "(1) Ensure efficient parts control operation.
- (2) Ensure maximum use of standard parts.
- (3) Minimize the number of different types and styles of parts used in the equipment or system.
- (4) Ensure timely implementation of parts decisions."<sup>39</sup>

When the contractor disputes the MPCAG findings, it is the PM's responsibility to resolve the issue.

DOD Directive 4120.3 requires tailoring of standards and specifications to buy only actual needs. Since the PM is responsible for the technical success of the equipment, the contractor can abuse the intent of the PCP by designing the system so that few standardization benefits are achievable.

For Fiscal Years 1982 and 1983, the DOD Inspector General (DODIG) discovered that MPCAG disapproved about 11.4% of the parts submitted because of duplication but that 88% of these rejections were ignored by the PM.<sup>40</sup> By FY 1985 the number of rejections had risen to 12.2%.<sup>41</sup> If the FY 1983 cost-avoidances of \$128.6M reported by the MPCAG resulting from replacement of nonstandard with standard parts are any indication of

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<sup>39</sup> MIL-STD-965, para 5.2.1.4.

<sup>40</sup> DOD Inspector General, DOD Parts Control Program Audit Report, DODIG Report 85-075, February 20, 1985, p 1.

<sup>41</sup> Defense Standardization and Specification Program, (DSSP) Fifty-Sixth Report to Congress, January 1986, p 15.

the program's success, one can wonder how much more would be realized had the PM's not overruled the recommendations.<sup>42</sup>

## H. PROVISIONING PROCESS

"Before provisioning, the DoD parts control program, using the military parts control advisory groups, shall be used to control the proliferation of items within the Department of Defense and to enhance standardization, reliability, and maintainability..."<sup>43</sup>

Provisioning Plans should begin at item conception. When the production contract is awarded the government may buy a technical data package providing information necessary for life-cycle support. The package is separated into Engineering Information, Procurement Data, and Technical Data for Provisioning. The information specifies "...descriptive and performance characteristics or features of items, materials, methods, practices, processes and services for development, production, use and support of end items."<sup>44</sup> Only the latter two, Procurement Data and Technical Data for Provisioning (TDP), are pertinent to this thesis since Engineering Information applies to production methods rather than follow-on support.

"...A procurement data package provides data necessary to control design, engineering, performance, and quality of an item sufficient to ensure functional and physical adequacy of the item for its intended

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<sup>42</sup> DODIG Report 85-075, p 2.

<sup>43</sup> DOD Instruction 4140.40, Provisioning of End Items of Material, June 28, 1983, enclosure (3) para C.

<sup>44</sup> DLAR 4185.1, Technical Data Requirements for Logistic Support, 2 September 1977, para IV.C.

application."<sup>45</sup> It includes engineering drawings, standards, specifications, purchase descriptions, purchasing data, functional data, item requirement sheets, commercial catalogs, item identifications...that provide data on interchangeability [and] substitutability..."<sup>46</sup> The package is some combination of Performance Specifications, where the contractor builds only to form, fit, or function, or Design Specification where the contractor is required to manufacture to an explicit design.<sup>47</sup>

TDP provides "...identification and quantity determination(s) of spare and repair parts necessary to support and maintain end items of material for specified periods...specific elements of cataloging, engineering, maintenance and supply support data,...technical data for provisioning contain information such as piece part relationship to next higher components and assemblies, prices of parts, parts population, and replacement and overhaul factors."<sup>48</sup>

Supplementary Provisioning Technical Data (SPTD) is a subset of Provisioning Technical Documentation (PTD) and is synonymous with TDP.<sup>49</sup> "...SPTD must be capable of providing for the:

- (a) technical identification of items for maintenance support considerations;
- (b) preparation of item identification for the purpose of assigning National Stock Numbers;

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<sup>45</sup> DLAR 4185.1, para IV.C.2.

<sup>46</sup> DLAR 4185.1, para IV.C.2.

<sup>47</sup> DLAR 4185.1, para IV.C.2.a-b.

<sup>48</sup> DLAR 4185.1, para IV.C.3.

<sup>49</sup> DLAR 4185.1, para IV.C.3.

- (c) review for item entry control;
- (d) standardization;
- (e) review for potential interchangeability and substitutability;
- (f) item management coding;
- (g) preparation of allowance or issue lists;
- (h) initial procurement from contractor or original manufacturer."<sup>50</sup>

As a part of the provisioning process, the government assigns Acquisition Method Codes (AMC) and Acquisition Method Suffix Codes (AMSC) to each part. The codes provide a screen delineating whether the government can compete the part or if the source is limited. Codes can be assigned requiring the government to purchase from the original manufacturer because of proprietary restrictions. Codes can also be assigned prohibiting procurement other than on a sole-source basis because the technical package is inadequate for competition.

Congress noted that inadequate technical data restrained efforts to compete.

"...Small businesses, in particular, indicate that they are precluded from competing for many government purchases because the government cannot provide them the data to manufacture a similar part. On the other hand, data in and of itself would not ensure that another contractor would be able to produce an equivalent part of the requisite quality. Evidence presented the committee indicates that the government's inability to retrieve data it is authorized to use and provide that information to a prospective contractor, and improper method coding of supplies, are the primary restraints on the government's ability to allow for competition for the contract.

The committee believes, however, that the government is unnecessarily restricted in its replenishment spare parts purchases by initial decisions not to acquire rights in technical data because of cost (without an appropriate assessment of

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<sup>50</sup> DOD Instruction 4151.7, Uniform Technical Documentation for Use in Provisioning of End Items of Material, undated, para G.7.

future savings) and by failure to plan adequately for future competition when initially acquiring a system."<sup>51</sup>

## I. CATALOGING

Congress, by legislation, tasked the Secretary of Defense with developing a single catalog system and standardizing supplies. The law specifically states that the DOD "...shall, to the highest degree practicable, standardize items used throughout the Department of Defense by developing and using single specifications, eliminating overlapping and duplicate specifications, and reducing the number of sizes and kinds of items that are generally similar."<sup>52</sup>

The Defense Logistics Service Center (DLSC) in Battle Creek, Michigan, is responsible for cataloging the 6 million spares and repair parts used throughout the DoD.<sup>53</sup> When a part is submitted to DLSC for National Stock Number (NSN) assignment, the manufacturer's Federal Supply Code for Manufacturers (FSCM) and part number (P/N) along with a full description of the part are checked for duplication. If DLSC determines that the FSCM and P/N are unique, it assigns the part a NSN. Frequently the PM only provides the FSCM and P/N because either the

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<sup>51</sup> Defense Spare Parts Procurement Reform Act, Committee on Armed Services Report, Report 98-690, April 18, 1984, p 15.

<sup>52</sup> USC Title 10 Chapter 145 Section 2451.

<sup>53</sup> James E. Fiene, Captain, US Air Force, The Feasibility of Using a Data Base Management System to Aid in Piece Part Standardization and Substitution, Thesis, Air Force Institute of Technology, September 1986, p 5.

contractor fails to provide the information [or PTD] or the service is in a hurry to field the equipment.<sup>54</sup>

The DLSC screen is dependent on the manufacturer using the same P/N in each application. "...If the contractor issues a new part number, or if the contractor has never previously contracted with the DOD, [DLSC] can do little to determine that this is a duplicate part."<sup>55</sup>

GAO found in March 1978 that only 37.7% of the items in the DLSC Catalog were fully described and the balance either partially described or lacked complete description.

"...Full characteristic descriptions establish the true identity of an item and differentiate it from every other item of supply. Thus, duplicate stock numbers can be recognized and eliminated and similar items can be selected and studied for elimination of those having dispensable differences. By comparison, partially described and reference type identifications are not complete. Because all characteristics are not documented, such items are not subject to the full range of item entry controls operating in the catalog system. As a result, new items are assigned national stock numbers and added to the catalog and supply systems even though identical and similar items are already in the catalog. This duplication can remain undetected because some controls designed to identify duplicate and unneeded items depend upon the presence of characteristic data. If items are not fully described, these controls are substantially weakened."<sup>56</sup>

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<sup>54</sup> Interview with Mr. Carl Bogar, General Accounting Office, Washington, D.C. Mr. Bogar had just completed an audit of the cataloging system for release by Fall 1987.

<sup>55</sup> Fiene, p 9.

<sup>56</sup> GAO Report LCD 79-403, p 53.

While 56.3% of DLSC catalogued material was fully described, items catalogued in the Navy supply system trailed all DOD agencies with a 15.6% rate.<sup>57</sup>

GAO estimated that 29% of the items submitted for DLSC screening in 1977 were duplicates. Furthermore, GAO pointed out that during a trial screen, between 1974 and 1977, of the material listed in DLSC catalogs, the same percentage were determined to be duplicates.<sup>58</sup> The material is entering the system because the lack of data prevents effective screening.

"...Defense and industry specialists generally agree that the most effective way to restrain the proliferation of new, unneeded items in the Federal catalog is to practice standardization at the time new equipment is designed. They realize that by the time item entry controls can operate, the Government has committed itself to buying equipment which, while meeting stated performance requirements, may contain many items for which the Government already has cataloged preferred substitutes."<sup>59</sup>

## J. CHAPTER SUMMARY

As the chapter has shown, guidance emanating from the federal and DOD levels supports the concepts of standardization. However, the manager is told that the mission need is the most important element and that nothing should impede this goal. After all, if the requirement can be satisfied with currently available equipment, then the procurement is not necessary. Consequently, desires for the state-of-the-art potentially can take precedence over other concerns.

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<sup>57</sup> General Accounting Office, Fragmented Management Delays Centralized Federal Cataloging and Standardization of 5 Million Supply Items, GAO Report LCD 79-403, March 15, 1979, p 53.

<sup>58</sup> GAO Report LCD 79-403, p 59-63.

<sup>59</sup> GAO Report LCD 79-403, p 11.

DSARC does not fully consider the long range impact on system supportability. The PM is expected to base decisions on the system's cost-effectiveness, but is not provided with any measurement guidelines. Therefore procurement costs provide the only meaningful indicator.

The PM is required to use, to the maximum extent possible, material currently available in DOD inventories. The MPCAG was created to assist in this effort. Since the manager is ultimately responsible for the project's success, and not bound by the MPCAG's recommendations, if the findings are not acceptable, then the PM can use whatever the contractor recommends.

Any lack of Provisioning Technical Documentation (PTD) impacts the ability of the system to provide proper life-cycle support. By default, the government must compete the procurement using only a performance specification. As parts purchased in this manner enter the system, new NSN's must be assigned, and the inventory range swells. An adequate PTD can reduce the number of new NSN's while providing cost savings by not buying parts common to other systems until sufficient demand triggers replenishment.



### **III. INVENTORY LEVEL IMPACTS**

#### **A. INTRODUCTION**

Chapter II summarized the applicable OMB, FAR, and DOD policies relative to standardization. It explained how a new part enters the system and the potential for duplication.

In this chapter, the impacts of non-standardization on Navy inventory levels will be addressed. It will first review Navy Guidance and the process for selecting parts. Next, it will assess the effects of competition on the inventory range. It will project Allowance Parts List (APL) and parts growth and estimate the potential number of duplicate parts either already in the Navy Supply System or entering in the near future. Finally, it concludes with a discussion of ongoing standardization programs.

#### **B. RESEARCH QUESTIONS**

This chapter will address the following research questions:

1. How does Navy policy affect inventory standardization?
2. What are the potential impacts on the Navy's inventory levels?
3. What is being done to implement standardization?

#### **C. NAVY GUIDANCE**

For the most part, Navy instructions support the goals of standardization. SECNAVINST 4120.3D states that:

"(a) Standardization shall be included in requirements for acquisition of systems and equipment.

- (b) Standardized designs shall be used, with inter- and intra-system standardization of hardware and engineering practices.
- (c) Existing components that are demonstrated to be reliable and supportable shall be applied in new designs.
- (d) Procurement provisions shall be used to restrain proliferation of types of components."<sup>60</sup>

When the implementing instruction for the SECNAV standardization policy was issued, NAVMAT stated that:

"...The Navy C/E [Component/Equipment] Program was established to curb the proliferation of components/equipment being introduced into the fleet. Proliferation of varieties of items is costly from the standpoint of economy, and efficiency of design, manufacturing and logistics. Frustrated maintenance efforts, increased logistics cost, and lack of versatility and supportability of equipment are typical of the impact on naval operating forces from a lack of standardization. Standardization of C/E is a means to reduce design and manufacturing costs, improve equipment maintenance, provide increased supportability and reduce life cycle costs. To provide for effective standardization of systems, subsystems, equipment, assemblies, components, parts and material, the Navy C/E program must be hardware oriented with increased emphasis on the concept of 'front-end' standardization (i.e. commencing standardization efforts at the beginning of the acquisition process)."<sup>61,62</sup>

The instruction further stated that "...effective and economical standardization controls [must] be developed and exercised during all phases of development, acquisition, and logistics support, to attain

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<sup>60</sup> SECNAVINST 4120.3D, Department of Defense Standardization and Specification Program (DSSP), 7 March 1980, para 3.

<sup>61</sup> NAVMATINST 4120.97B, Standardization of Components/Equipment (C/E) used by naval operating forces, afloat and ashore, 7 May 1984, para 4.

<sup>62</sup> Throughout the thesis references will be made to NAVMAT instructions. Although NAVMAT has been dis-established, many of these references remain valid.

an optimum degree of standardization and limit the variety of C/E used in weapons systems/equipment...This requires:

- (a) Including hardware standardization requirements in concept formulation, design, engineering, acquisition, production, conversion, modernization and alternation.
- (b) Promoting inter and intra (C/E) standardization for system designs, hardware and engineering practices.
- (c) Use of (in new designs) existing, reliable and supportable C/E already supported by the military service.
- (d) Restricting use of limited application C/E.
- (e) Exercising configuration control to maintain standardization.
- (f) Using procurement techniques to restrain proliferation.
- (g) Effecting item entry control for new C/E in design, selection, and provisioning phases of material acquisition.
- (h) Backfitting standardization into existing systems to maximum extent practicable.
- (i) Maintaining a standardization program which is hardware oriented and recognizes that standardization is but one of many important equipment selection criteria (i.e., life cycle costs, manning, reliability, maintainability, availability, competitive procurement and industrial ability/capability)."<sup>63</sup>

This last statement points to the inability of the instruction's author to recognize the impact that standardization has on all the other criteria. Increased use can reduce life-cycle costs and manning requirements while improving the remainder.

NAVMAT also issued implementing guidance for the DOD Parts Control Program. In the related instruction NAVMAT stated that "...Use of the DOD Parts Control Program results in cost avoidance to the Navy by:

- (a) Reducing the need for contractor-prepared drawings and specifications for nonstandard parts.
- (b) Reducing redundant nonstandard parts-testing.

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<sup>63</sup> NAVMATINST 4120.97B, para 6.

- (c) Eliminating the logistic support costs that would have accrued had the nonstandard parts entered the Logistic System.
- (d) Reducing field maintenance costs through the use of more reliable parts."<sup>64</sup>

To achieve the objectives of the DOD PCP, according to the NAVMAT Instruction, requires "...the application of techniques that will:

- (a) Provide to system or equipment acquisition program managers and their contractors methods for the selection of preferred parts.
- (b) Enhance inter/intra-departmental equipment/parts standardization and interchangeability.
- (c) Minimize the variety of parts used in new designs."<sup>65</sup>

Additionally the instruction required the Hardware Systems Commands to:

"...Enforce use of the parts control program requirements in all major system development contracts and other development, production or modification contracts when it is foreseen that life-cycle cost benefits can be derived."<sup>66</sup>

Despite the specificity of the SECNAV and NAVMAT Instructions, NAVSEA, in particular, excluded shipbuilding contracts from compliance with the DOD PCP in keeping with their long-standing attitude.<sup>67</sup> For example, a 1973 Naval Audit Service report found that 40% of all nonstandard items were generated during new construction.<sup>68</sup>

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<sup>64</sup> NAVMATINST 4120.106A, DOD Parts Control Program, 26 October 1981, para 3b.

<sup>65</sup> NAVMATINST 4120.106A, para 5a.

<sup>66</sup> NAVMATINST 4120.106A, para 5b(2).

<sup>67</sup> NAVSEAINST 4120.4A, Department of Defense Parts Control Program, 3 June 1983, para 3b. The instruction was superseded by NAVSEAINST 4120.4B of 25 August 1986. Shipbuilding must now comply with DOD PCP.

<sup>68</sup> Naval Audit Service (Northwest Region), Service-Wide Audit of Standardization of Components for Ships, report number 150033, 19

According to the Executive Director of SPCC, NAVSEA does not motivate the designer or builder. PM's and Naval Ship Yards (NSY) are evaluated on their ability to deliver the equipment by a certain date at, or below, budget. Total operating costs are not a factor. Furthermore, contractors do not have an incentive to implement a standardization program. An early attempt to provide the contractor with an incentive was unsuccessful. On the USS EISENHOWER contract (which exceeded \$1B), Newport News Shipbuilding was offered \$86K to incorporate standard equipment and parts. It would cost the contractor more to comply with the requirement than the return generated, thus it failed to provide a true incentive.<sup>69</sup>

There is a standardization office at NAVSEA. However, it does not perform any equipment analysis to evaluate potential for standardization nor do they initiate any reduction studies. Its primary role is to review contract specifications to ensure correct citation. In addition, it appears that the NAVSEA Standardization Office contributes significantly to the proliferation of non-standard items.<sup>70</sup>

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December 1973, p 15. Despite the report's age, Mr Stanley Zatorski, the Auditor-in-Charge of a 1979 report on the same topic, did not find reason for change. Interview with Mr. Zatorski, May 22, 1987. Additional research by the author does not dispute the 1973 findings. Comparison of equipment proliferation figures in the 1973 report with a 1986 Naval Sea Systems Logistics Center "Fleet Standardization Profiles" report shows an increase in the number of new non-standard equipment.

<sup>69</sup> Interview with Mr. R. B. McFarland, Executive Director, SPCC, May 19, 1987.

<sup>70</sup> Interview with Mr. Steve Lowell, DMSSO, July 6, 1987. Mr. Lowell, who was formerly employed in the NAVSEA Standardization Office, noted that the office does not have any full-time engineers that review for non-standard equipment or parts. On the other hand, the

#### D. PART SELECTION PROCESS

In the previous section, it was argued that despite the numerous instructions requiring standard parts, NAVSEA would seem to be contributing to the problem through inadequate internal guidance. This section will address the problems within the equipment selection process that took advantage of the NAVSEA policy and contributed to proliferation.

Initial design and equipment selection is done by the NAVSEA engineer in the project office. Once the plans have been approved, the engineer at the lead shipyard prepares the Basic Alteration Class Drawings. The drawings provide a detailed list of the material required for the first ship, and are the baseline for subsequent ships.<sup>71</sup> When developing the drawings the engineer generally uses two reference sources for equipment selection. The first, the NAVSEA Standard Component List (NSCL), provides population data and standard descriptions. However, since the information is maintained on microfiche and the research tedious and time consuming, it is not used to its fullest extent.<sup>72</sup>

The second reference source, the Master Index of Allowance Parts Lists (MIAPL), is also maintained on microfiche. While the NSCL only supplies equipment related information, the MIAPL breaks the information down to NSN's. The engineer must know the NSN of the C/E or the APL number to access the related drawing. It is a manual process; the NAVAIR Standardization Office has approximately 100 engineers that initiate studies and review designs.

<sup>71</sup> Naval Audit Service Report, I50033, p 14.

<sup>72</sup> Interview with Mr. Larry Tapp, Superintendent of Shipbuilding, New Orleans, LA., June 1987.

MIAPL does not have the facilities for accessing the information through Form, Fit, and Function (F<sup>3</sup>) specifications. The engineer does not like to use either, but considers the MIAPL the least desirable of the two sources.<sup>73</sup>

The use of a centralized computer data base to aid in the search is not new. In 1970, a congressional report entitled "Military Supply Systems: Cataloging, Standardization and Provisioning of Spare Parts" recommended the development of an automated system to provide designers with standard C/E information. However, the cost of the system and the physical size made its development impractical.<sup>74</sup>

Captain Fiene evaluated two less complex systems. The first, Technical Logistics Reference Network (TLRN), was developed in 1973 by Innovative Technology Incorporated (ITI). Initially designed to reduce procurement and support costs, the system has the capability of performing a characteristic search. Presently, TLRN is the only system that can interrogate the entire DOD inventory by part description.<sup>75</sup> The system, however, is slow. It screens for one characteristic at a time and the first pass can take as long as 2-3 hours. "It is not uncommon for a complete search for a part on this system to take as long as five hours."<sup>76</sup>

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<sup>73</sup> Ibid.

<sup>74</sup> Fiene, p 25.

<sup>75</sup> Fiene, p 17-18, and 62.

<sup>76</sup> Fiene, p 29.

The second system was the Characteristic Search System which is part of the DLA Network. The system, developed by DLSC, is limited to searching for ten characteristics even though the engineer frequently requires more than the limit. In a test, Captain Fiene searched for 35 fasteners, each with seven characteristics. He averaged 9.5 minutes per part, a considerable time saved over the TLRN search of 5 hours.<sup>77</sup> Unfortunately, he noted that "...There have been no plans made to implement this system at the engineering working levels."<sup>78</sup>

Finally, he points out

"...it can take as little as 30 minutes to write up justification for using a piece part not listed in the DOD supply catalog. Weigh this against taking a week to manually search for a substitute from the DOD supply catalog, when it is not even known if a substitute exists, and it is not hard to understand why the design engineer may not always build this type of standardization into a design."<sup>79</sup>

Based on the discussion in this section, the Naval Audit Service finding is not surprising:

"...our review indicated that selections were based primarily on engineering knowledge of specific commercial products that met the alteration or repair requirements, without considering the adaptability of existing standard equipment."<sup>80</sup>

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<sup>77</sup> Fiene, p 65.

<sup>78</sup> Fiene, p 22 and 64.

<sup>79</sup> Fiene, p 13.

<sup>80</sup> Naval Audit Service (Northeast Region), Service-Wide Audit of Replacement Components for Installation on U.S. Navy Ships (Standardization), Audit Report I20047, 5 September 1979, p 5.



## E. EFFECTS OF COMPETITION

Standardization and competition are not conflicting efforts. In fact standardization can boost competition by reducing the variety of parts while simultaneously increasing the quantity of each buy. Experience has shown that there is more interest by the manufacturer in competing for larger orders, and savings from competition are well-documented.

Another way that competition has increased has been through contracts citing performance rather than detailed design specifications. This does not intend to imply that considering form, fit, and function (F<sup>3</sup>) excludes design specifications. In fact, as the U.S. Army Material Systems Analysis Activity (AMSAA) notes, F<sup>3</sup> can run the gamut from pure design to performance specifications.<sup>81</sup> However, according to the AMSAA study, the use of F<sup>3</sup> specifications, which allow the contractor to design the item, increases the potential for competition and enables the government to incorporate improved technology faster.<sup>82</sup>

The AMSAA study did find that the use of F<sup>3</sup> reduced standardization and led to additional NSN's. It also found that the increased configuration can lead to maintenance problems, especially for repairable material, and concluded that F<sup>3</sup> was better suited for generic, non-repairable items.<sup>83</sup>

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<sup>81</sup> U.S. Army Material Systems Analysis Activity, Form, Fit, and Function (FFF) Study, AMC Task Number 83-14, November 1984, p II.

<sup>82</sup> AMSAA study, p 13.

<sup>83</sup> AMSAA study, p 31-61.

The latter observation was supported by SPCC personnel. They cite repair problems on Shipboard Air Conditioning Units where equipment was bought based on performance specifications. When the sailor tried to repair it the insides of the "black-box" differed from the technical manuals which also differed from equipment at the schools. Additionally, the ship may have more than one piece of equipment onboard and that there was a good chance that the P-250 Pumps or the Air Conditioning units were not identical. Consequently, the ship has to carry a greater range of parts if the installed population is sufficient to justify it. By reducing the variety of equipment and the supporting range, depth of spares could be increased and material availability improved.<sup>84</sup>

#### F. APL AND PARTS PROLIFERATION

Now that the root of the proliferation problem has been established, it is necessary to assess the impacts on the Navy's inventory levels. If one makes the assumption that APL growth directly corresponds with equipment introductions, then it is possible to forecast the proliferation of parts within the Navy Supply System. However, the author was concerned that examination of the total parts population might hide any trends within the equipment population. Therefore, the data was segregated into related groups and the equipment growth within the groups was then measured to develop a forecast.

APL's for H,M&E are categorized into 89 Commodity Classes (CC) (e.g. Valves, Motors, Pumps, and Controllers) within the Weapon System

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<sup>84</sup> Interview with Messrs. George Blackmore, and William Bunge, Equipment Specialist, SPCC, May 18, 1987.

File (WSF) at SPCC. Since all 188,731 H,M&E APL's are broken into commodity classes, the information presented in the CC format was used to analyze the equipment data.

Data was available on the annual number of new APL's within each CC from 1977 to 1986 and was used to compute the average annual growth for each CC. Forty-four of the 89 (49.44%) classes showed an average growth that exceeded the aggregate average over all CC's in at least 4 of the last 5 years (starting in 1982).

A regression analysis was performed next in an attempt to determine if the annual additions to the APL population for each of the 44 above average growth rate CC's was a function of the total annual fleet population and deliveries of new ships.<sup>85</sup>

The results of the regression analyses did not fully support the contention that the trends in the 44 CC's were directly attributable to fleet expansion. Only 14 of the 44 items (22.7%) had an R-Squared value greater than 70% when regressed on fleet expansion.<sup>86</sup> Therefore other

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<sup>85</sup> Ships completing Restricted Overhaul (ROH) were also considered since the Naval Audit Service finding that 60% of new equipment were added during overhaul. However, ROH's were omitted since the number steadily declined from 1977 and the number was "...expected to stay at the same low level or ...decline in the years ahead, as more ships are phased into engineering operating cycles and phased maintenance programmes." [Jane's Fighting Ships 1986-1987, p 688.] As the number of ROH's declines there will be an increase in shorter, but more frequent Ship Restricted Availability (SRA) to perform upkeep maintenance that would otherwise be restricted to ROH. Because data for both ROH and SRA were not available beyond the past five years, it was not possible to test correlation with APL proliferation.

<sup>86</sup> 70% was selected over the traditionally accepted R-Squared of 80% since the T-Ratios for these items were strong and indicated a

causes for the growth of the remaining 30 were investigated. Data was separately regressed against 1) total ship population, and 2) new deliveries and total ship population. If the CC had an R-Square greater than 70% and a T-Ratio greater than 2 for the latter regression, then the formula for computing APL growth included both variables. If the results only met the R-Square criterion, then the formula ignored new deliveries.

To compute the potential APL growth, 3 selection criteria were used. First, if the CC had an R-Squared for greater than 70%, the ship population for the following years was factored according to the computation derived from the regression model. Second, it was assumed that the growth from the past five years for CC's that showed the above average trend but were not correlated to ship population, would remain constant. As a result, the average annual growth since 1982 was accepted as the predictive value. Finally, along the same lines, the average annual growth of the remaining 45 CC's over the past 10 years was assumed to be constant and therefore used to compute future growth.

The formula for estimating the APL growth, of those items correlated with ship population and/or new deliveries, was:

$$\text{APL Growth} = \text{Constant} + \text{Ship Population}(X_1) + \text{New Deliveries}(X_2).$$

where  $X_1$  is the coefficient for ship population for each CC, and  
 $X_2$  is the coefficient for new deliveries for each CC.

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significant regression. Using 70% as a baseline implied that less than 30% of the increase was explained by other factors and the author considered that to be acceptable. Changing the R-Squared value to 80% would have left only 6 items that could be explained by the increase in the population. Using 60% would have increased the acceptable regressions to 21.

For example, Controllers (CC 15) had an R-Square value of 90.7%. Its 1987 APL growth was 782.9 and was computed by:

$$-2,877 + 569(6.6062) + 13(-7.62)$$

where 569 is the 1987 ship population and 13 is the number of new ships delivered to the Navy in 1987.

Next, Pumps, CC 01, which showed an above average growth trend but was not correlated to ship population, grew an average of 479 new pumps in the past five years. Therefore, as it was assumed that this trend would continue, the value of 479 was used to estimate the 1987 pump growth.

Finally, Condensers, CC 04, was a member of the 45 slow growing CC's, and grew an average of only 11 equipment per year for the past 10 years. Thus, its growth was assumed to remain constant at 11 in 1987.

From the results of the regression analyses, the forecasted total aggregate APL growth is:

| Year | Forecasted<br>APL Growth |
|------|--------------------------|
| 1987 | 10,737                   |
| 1988 | 10,955                   |
| 1989 | 11,549                   |

The figures far exceed the average of 8,778 used by NSLC, but are less than the actual growth for 1986.<sup>87</sup>

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<sup>87</sup> NSLC computes the annual growth by averaging the growth of the individual CC's and aggregating the results. Using the data from the past 10 years, NSLC estimates that the APL population will grow by 8,778 in 1987. Interview with Mr. Richard Jones, May 18-22, 1987.

The next step, was to calculate the number of additional parts that can be expected to result from the forecasted increase in equipment. Historically, when a piece of H,M&E equipment is introduced, 25% of its parts are new to the supply system. (For electronic equipment it is 15%.) The average number of parts per equipment within each CC is also known.<sup>88</sup> It was then a matter of multiplying the forecasted number of APL's per CC by the parts/equipment and then by 25% to compute the expected number of new H,M&E parts being added each year to the Navy Supply System.

Using the forecasted 1987 - 1989 APL growth values projected a parts range growth of:

| Year | Projected<br>Parts Growth |
|------|---------------------------|
| 1987 | 39,034                    |
| 1988 | 40,006                    |
| 1989 | 42,295                    |

Ignoring reductions resulting from obsolescence and assuming approximately 600,000 line items are managed by SPCC, this equates to an annual parts growth of over 6% for any of the three years. With the emphasis on streamlining and funding reductions, the additional parts add an unwanted burden to an already strained system.

Data and complete regression analysis results are provided in Appendix A.

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<sup>88</sup> Interview with Mr. Richard Jones, May 18-22, 1987.

## G. EXTENT OF DUPLICATION

In Chapter II it was shown that approximately 29% of the material in the DLSC Catalog is duplicate. As mentioned earlier, the Navy currently manages 188,731 different H,M&E equipment, but the number that are duplicate are unknown. Determining the number of duplicates requires the availability of files giving details for each equipment. Such data are maintained in the SPCC Weapon System File (WSF). However, it was not possible to screen the WSF since it is not structured to permit easy access by functional specifications.<sup>89</sup> The NAVSEA Logistics Center (NSLC) has developed the capability for querying the WSF by Commodity Class (CC) to obtain this data. It is being placed in NAVSEA's Component Characteristic File (CCF). However, since the CCF project is still being installed, not all information for all classes have been transferred into the CCF (e.g. within the CC for Pumps, 88.37% of capacity specifications have been transferred, while only 4% of the intake connection types transfers have been completed).

As it was not possible to screen the entire data base for duplicate equipment, it was necessary to select a representative commodity class. The findings were then extrapolated to estimate the number of duplicate equipment in the entire population. The CC 01, Pumps, was chosen since more data was available than for the other classes, and it was assumed that the size was sufficiently large to represent all equipment. The file was searched based on Lead Allowance Parts List (LAPL) description,

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<sup>89</sup> NSLC is restructuring the files to provide the customer with the capability to access the data. It is scheduled for completion by the end of 1987. Interview with Mr. Richard Jones, NSLC, May 18-22, 1987.

Gallons Per Minute (GPM), and Pounds Per Square Inch (PSI).<sup>90</sup> The data was then segregated by the number of Allowance Parts Lists (APL), Fleet Population (number of installed equipment in the fleet) and Ship Population (the number of ships with the installed equipment).

The data resulted in identification of 3,116 different pumps with similar functions. Initially, 2,376 pumps with only one APL were eliminated since they were obviously not duplicates (e.g. a centrifugal pump, boiler feed with a capacity of 655 GPM and 775 PSI). Then 8 more were eliminated since they were no longer installed. This left 732 pumps with differing GPM/PSI combinations for further examination.

The equipment was segregated by the number of APL's per similar function, and then categorized by the number of different GPM/PSI combinations. For instance, there are 2 different APL's for pumps capable of pumping 460 GPM at 1,460 PSI. (There was a total of 447 different GPM/PSI combinations, each with 2 different APL's.)

In Chapter II it was noted that GAO estimated that 29% of the items in the DLSC Catalog were duplicate. From a conservative perspective it was felt that 25% rather than 29% would yield results more acceptable to skeptical readers. Categories that had 4 or more APL's with similar characteristics were then multiplied by 25% to compute the potential number of duplicates. Assuming that there had to be duplication in the

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<sup>90</sup> The data was not specified other than the generics of LAPL, GPM and PSI so it is not possible to differentiate, for instance, whether the equipment were designed to pump water, gasoline, or oil.



categories that had only 2 or 3 APL's, an arbitrary value of 10% rather than 25% was used to compute potential duplicates.<sup>91</sup>

Based on the above assumptions, the results indicated that there were potentially 373 pumps that are identical or 5% (373/7,400) in the 01 CC. Assuming a comparable 5% for the remaining CC's, there are potentially 9,513 duplicate equipment managed by the Navy. A one-time elimination of the duplicates offers potential savings and substantially reduces the range of parts managed in the Navy Supply System.

Data used to develop the estimates and results for the Pump class (01 CC) are provided in Appendix B.

Assuming the number of duplicate equipment has been estimated correctly, the range of parts that may then be eliminated from system inventory can be estimated. Earlier it was estimated that 25% of the parts in each APL are new to the supply system when the equipment is introduced. If the 9,513 duplicate APL's are multiplied by the number of parts per equipment (as was done in section F to compute the parts growth) and the 25% factor applied, then 29,268 new parts could be potentially eliminated from entering the inventory system.

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<sup>91</sup> A rule of thumb in private industry is that 10% of equipment with comparable low populations (as exhibited by equipments with only 2 or 3 APL's) are duplicate. Interview with Dr. David R. Whipple, Naval Postgraduate School, Monterey, CA, June 1987.

Applying the same logic to the table of section F, the potential reductions for 1987 - 1989 could be:

| <u>Year</u> | <u>Duplicate APL's</u> | <u>New Parts</u> |
|-------------|------------------------|------------------|
| 1987        | 541                    | 1,968            |
| 1988        | 552                    | 2,017            |
| 1989        | 582                    | 2,132            |

While this may not appear to be a major issue, as Chapter IV shows, it offers the opportunity for significant potential cost savings.

The results of the duplicate part estimates by commodity class are provided in Appendix C.

## H. SUBSTITUTABILITY

When a new item enters the system it is assigned to a family group according to the DOD interchangeability and substitutability process. The item most currently assigned to the family becomes the head of the group. As material is requisitioned, the requested item is issued but the demand is recorded against the family head. Replenishment inventory is then procured for the family head.<sup>92</sup>

One of the benefits of standardization purported in Chapter II is that inventory depth can be increased because the range is decreased. This implies that material availability for parts with substitutability and interchangeability (S/I) should be better than for parts without this feature.

To test this theory the WSF was queried, comparing backorders of items with S/I against parts that lacked this feature. Backorders were

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<sup>92</sup> Interview with LCDR Poe, May 18-22, 1987.

selected as a means of measurement since, in theory, S/I material should be able to satisfy more demand and therefore have relatively fewer outstanding procurements. If that were the case, then Supply Material Availability (SMA) (the percentage of demands satisfied immediately) for S/I items should be better than for non-S/I parts.

Only SPCC managed 1 (consumables) and 7 (repairables) Cog family items that had 10 or more NSN's and 3 or more demands per year were selected as S/I candidates. These items were chosen for two reasons. The first was that the greater the number of NSN's within the family, the greater the opportunity to satisfy demand. Second, and more importantly, using families of 10 or more NSN's reduced the population screened and made data analysis more manageable.

The results of the comparison did not prove that material availability was improved for S/I items. For the 341 S/I NSN's (Family Heads), there were 3,056 backorders whereas the 633 non-S/I NSN's experienced 5,657 backorders. S/I items had 8.96 backorders per NSN versus 8.94 per NSN for the latter, an insignificant difference. It is beyond the scope of this thesis to determine the reasons for the results, but it can be surmised that non-S/I NSN's received increased managerial attention.

## **I. ONGOING STANDARDIZATION PROGRAMS**

Approximately 10 years ago NAVSEA initiated the Navy Standard Valve Program to standardize valves with diameters of two inches and under. At that time there were 153 APL's for valves of this size, and the Navy was achieving only a 50% Supply Material Availability (SMA). Through

the use of standardization the number of APL's dropped from 153 valves with a range of 5 parts each to 24 with a range of 12 parts while SMA exceeded 99%.

Standardization also resulted in competition increasing significantly. Twenty manufacturers bid on Navy design specifications and 5 companies were awarded contracts for the initial buy of 213,290 valves. The combination of competition and volume also permitted the manufacturers to reduce the procurement costs, off the original estimates, by 51% to \$12.1 million and increase product quality. The latter has resulted in substantial life-cycle cost avoidance. Because of the value engineering improvements, it is estimated that each valve can be repaired at least five times before it is replaced. Estimates for the previous valves showed that they could not be repaired more than approximately 2 times. As a result it is estimated that the Navy will save over \$700 million dollars over the life of just the originally procured valves.<sup>93</sup>

The P-250 Pump is a portable fire fighting/damage control pump installed on every surface ship in the Navy and Coast Guard. There are six different P-250 pumps in the fleet. The pumps, each with an expected life of two years, had been procured by performance specifications. As a result, on an average destroyer that has three P-250's, each pump may be different and the parts not interchangeable. The range of equipment reduced the inventory depth that the ship carried in

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<sup>93</sup> Interview with LCDR Robert Burtherus, SC, USN, SPCC and SPCC Memorandum 4400, Ser 0514/510, May 30, 1985.

stock so that when the pumps failed there was a strong possibility that the part was not in stock.

Since damage control is vital for the ship to complete its primary mission, SPCC initiated a program to standardize the pump in 1983. Using a government owned design package, SPCC competitively procured 5,000 units reducing the acquisition costs from \$9,100 to \$4,600 each (for a procurement savings of \$22.5M) while improving the estimated reliability by 50%. Furthermore, because the APL's were reduced from 10 to 3, SPCC was able to increase depth since it was not necessary to spread funds across as great a range of parts.<sup>94</sup>

There is a fire pump installed in the engine room of every surface ship. The procurement costs of the 64 different pumps range from \$60 to 80K each, with an economical repair cost between \$45 and 60K per unit. In an effort to reduce the equipment variety, NAVSEA recently purchased the unlimited technical data rights to a titanium fire pump. Consequently the APL's were reduced from 64 to 2 and the number of wearing parts from 175 to 7. The procurement quantity of 1,328 pumps enabled the Navy to take advantage of volume discounts, cutting the acquisition costs to \$26K each. At this price it is now cheaper to replace the old pumps rather than repair them.

The success of these three programs occurred because the Navy purchased technical data packages that enabled every contractor to deliver

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<sup>94</sup> Interview with Messrs. George Blackmore, and William Bunge, SPCC, May 18, 1987.

identical equipment. The reduction in the equipment range increased the volume for each procurement and resulted in substantial cost savings.<sup>95</sup>

Unfortunately, NAVSEA's philosophy on standardization is not consistent. For example, NAVSEA recently "de-standardized" the LM2500 Gas Turbine Engine, the power plant for the KIDD (DDG-993), SPRUANCE (DD-963), PERRY (FFG-7), BURKE (DDG-52), and TICONDEROGA (CG-47) Class ships. In its original configuration, the LM2500 is installed in over 95 ships. However, in an effort to improve the power, the Ship Acquisition Project Manager (SHAPM) switched from a double to a single shank starting with the CG-52 and a non-interchangeable fuel control on the DDG-57. SPCC initially managed 4,000 parts to support the engine. The changes increased the range by 20% to 4,800 parts, at an approximate additional cost of \$320K per engine.<sup>96</sup>

It is the SHAPM's prerogative to make such decisions when the long term benefits exceed the cost. Standardization should be only one of the considerations in that decision. However, PTD must be purchased to coincide with the changing configuration if the equipment is to be properly supported during its life. In the LM2500 situation, engine modifications are currently being installed without support as the technical data package was only recently delivered. It is estimated that it will take 4 years for

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<sup>95</sup> Ibid.

<sup>96</sup> Interview with Mr. Jerry Lusk, LM2500 Manager, SPCC, May 18, 1987. The additional spares cost was computed by taking the \$1.6M estimated as the cost of parts to support the engine and dividing by the 4,000 parts to compute the average cost per part. The cost/part was then multiplied by the 800 new parts (20% of the 4,000) to arrive at \$320K.

the supply system to provide adequate inventory support for the parts.<sup>97</sup> In the LM2500 case, since the supply system may have to acquire parts based only on performance specifications, the decision to delay data procurement may ultimately contribute significantly to parts proliferation.

## J. CHAPTER SUMMARY

Despite the specific directions from SECNAV and NAVMAT, past NAVSEA policy and actions have effectively resisted efforts to standardize, thus significantly contributing to inventory growth. In addition, PM's and builders are not sufficiently motivated and shipyards do not have the tools that will enable engineers to identify standard parts. As the projections show, this has resulted in an expansion of the inventory. Continuation of the growth can detrimentally impact fleet material readiness.

Recently NAVSEA took some steps to standardize (i.e. the pumps) with considerable success. The success of these standardization efforts demonstrates that the program is effective and leads to substantial payoffs.

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<sup>97</sup> Interview with Mr. Jerry Lusk, LM2500 Manager, SPCC, May 18, 1987. Mr. Lusk noted that the PM had not made provisions for interim support but was depending on the warranty to provide parts. The question must then be raised about parts support while the ship is underway unless the contractor is willing to provide every platform with a repair kit.

## **IV. COST ANALYSIS MODELS**

### **A. INTRODUCTION**

Chapter II discussed the requirement for making decisions on a cost-effective basis. In Chapter III the problem with parts proliferation was discussed. Costs are the driver in most decisions, but in neither chapter was the subject explicitly addressed. In this chapter the costs of standardization will be explored. First, three current models for measuring standardization costs will be reviewed. Next, a new model will be proposed that incorporates factors not considered by the other three models. Using the proposed model, the costs for non-standardization will be computed and the implications of the resulting non-standardization costs analyzed. Finally, the chapter will conclude with a brief discussion of the factors that must be considered in the decision to purchase Provisioning Technical Documentation (PTD).<sup>98</sup>

### **B. RESEARCH QUESTIONS**

This chapter will address the following research questions:

1. What standardization costing models are available as tools in the decision process?
2. What are the costs and impacts of non-standardization?

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<sup>98</sup> For a thorough discussion of life-cycle costing, LCDR David L. Porter's thesis, Controlling Life-Cycle Cost: A Management Perspective, provides an outstanding analysis of the subject, and is highly recommended.



## C. COSTING MODELS

### 1. NAVSEA Logistics Center (NSLC) Model

DOD and Navy guidance reviewed in the previous chapters specifically stated that system procurements must be cost-effective. However, nowhere is the means for measuring cost-effectiveness provided. The PM's therefore need a means for analyzing the ILS cost associated with the introduction of new equipment and for measuring the cost-effectiveness of procuring PTD. Mr. Richard Jones of NSLC has developed such a tool.

In developing the NSLC model, the following factors were determined to be important initial ILS costs related to standardization:<sup>99</sup>

- "(a) PTD
- (b) Provisioning
- (c) NSN/APL Maintenance
- (d) Training
- (e) Technical Manuals
- (f) Installation Drawings
- (g) Configuration Control
- (h) Testing
- (i) Planned Maintenance."

The model was developed to be a part of the Request For Proposal (RFP) package. The premise is that the contractor would calculate the values for the factors based on a standard set of numbers. In that manner all competitors would be working from the same baseline. In line with A-109, the PM could then add the ILS costs to the acquisition costs to fairly assess the true costs for operating the contractor's proposed system.

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<sup>99</sup> Unless otherwise noted, the discussion of the NSLC model is taken from Mr. Richard Jones' paper H,M&E Standardization.

Should a contractor with the lowest bid lose the contract because total operating costs were higher, the government could potentially be sued. Therefore, the model was developed using formulas generally accepted throughout the defense industry.<sup>100</sup>

The resulting model is:

$$C = 950 + 171.25(P) + 67.2(P)(L) + PR(L) + 1000(CL) + 20(Pop) - 2(PR),$$

where C represents total ILS costs,

P is the number of different parts in the equipment,

L is the projected life-cycle of the equipment in years,

PR is the equipment unit price,

CL is the number of classes of ships per installation, and

Pop is the number of ships.

A detailed explanation of the model is provided in Appendix D.

## 2. Defense Electronic Supply Center (DESC) Model

A second model was developed by Mr. Charles E. Gastineau of the Defense Electronics Supply Center (DESC). He found that four factors account for 80% of the total life-cycle costs of a part related to standardization. They are:

- "(a) The cost of preparing a document that describes the nonstandard part, taking into account the labor charges, overhead, burden, and other charges related to document preparation.
- (b) The cost to test nonstandard parts which represents a major portion of the cost...
- (c) The cost of managing a part in the inventory which includes the cost of provisioning meetings, computer layout sheets, etc.

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<sup>100</sup> Interview with Mr. Richard Jones, NSLC, Mechanicsburg, PA, May 17-22, 1987.

- (d) The cost incurred in maintenance owing to the reliability or unreliability of a nonstandard part. This too is a major cost..."<sup>101</sup>

Using the results of two studies, Mr. Gastineau then developed a simplified technique for analyzing the cost-effectiveness for applying standardization.<sup>102,103</sup>

The resulting model is:

$$CA = (MH)(\$/MH)(\%ND) + (\%PT)(\$/T) + [(\$/C) + (y)(M\$/y)](\%ND)(NPN) + (y)(\$/R/y),$$

where CA represents the total ILS costs,  
MH is the number of manhours,  
\$/MH is the cost per MH,  
%ND is the percentage of drawings needed for the new parts,  
%PT is the percentage of parts tested which were new parts,  
\$/T is the average cost per test,  
\$/C is the cost to catalog (a one-time charge),  
y is the number of years,  
M\$/y is the management cost per year,  
NPN is the number of new parts per drawing, and  
\$/R/y is the annual repair costs.

A detailed explanation is provided in Appendix E.

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<sup>101</sup> Charles E. Gastineau and Donald L. Kerr, "Don't Cry: Justify", from The Economics of Standardization, edited by Robert B. Toth, p 63.

<sup>102</sup> The two studies used were: (1) Charles L. McElroy and Ralph T. Rognlie, A Mathematical Model for Determination of Benefits Derived from Standardization of Electronic Parts and Components, Master's Thesis, Air Force Institute of Technology, August 1969, and (2) National Aerospace Standards Committee, Aerospace Industries Association, Standardization Savings, Identification and Calculation, NAS1524, 31 August 1970. The first reference was cited by Messrs. Gastineau and Kerr in the article "Don't Cry : Justify". The second reference appears as an appendix in The Economics of Standardization.

<sup>103</sup> Unless otherwise noted, information for this discussion is taken from Messrs. Gastineau's and Kerr's article.

### 3. Aerospace Industries Association of America (AIAA)

The Aerospace Industries Association of America (AIAA) developed a third model, using nine factors, that provided the basis for the DESC model. It assumed that savings from standardization would be accrued from:

- (a) Increased quantity purchases,
- (b) Reduced paperwork and handling,
- (c) Reduced storage requirements,
- (d) Reduced engineering search time,
- (e) Using a standard stock part rather than establishing a new standard,
- (f) Using a standard stock part in lieu of a new design,
- (g) Reduction of the inventory range,
- (h) Using a stocked standard part in lieu of a nonstocked part, and
- (i) Using a known design rather than detailing the data completely for a new part on the drawing.

The model requires an extensive amount of data and thus does not meet the simplification criteria necessary for PM acceptance. It is more applicable in decisions to standardize material already carried in inventory. The model is summarized in Appendix F.

### 4. Model Analysis

If any model is going to be accepted by the PM, then its results must provide valid numbers that can be used in decisions. To test the validity of the NSLC and DESC models, the author ran both models using common data.<sup>104</sup> If the results were proximate, then it could be assumed that both models provided the PM with a simplified tool. The manager could then select either one.

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<sup>104</sup> The AIAA model was not tested. It is more applicable in the decision to standardize equipment or parts already in use rather than estimating the cost for introducing new equipment. The latter is the goal of the NSLC or DESC models.

Mr. Gastineau assumed that each part had a life of ten years before it was redesigned or eliminated from inventory. The ten-year assumption was therefore used for both models. All costs were inflated from their base year by a 5% annual rate. The 1987-1989 APL/part growth projected in Chapter III provided three different values for the number of parts to be introduced annually. Since less than 75% of all APL's are installed on five or less ships, it was assumed that the each equipment was installed on five ships and, with such a low equipment distribution, all five ships were assumed to be from the same class. The NSLC model assumes that training ceases four years prior to equipment phase-out. If a 20-year life expectancy is used, then four years is logical. However, using only a 10-year life, training was assumed to stop two years prior to phase-out. Finally, as Mr. Gastineau observed, the four elements used in the DESC model accounted for only 80% of costs. Therefore, the DESC values were increased by dividing the results by 80%.

The models provided the following estimates of costs resulting from non-standardization:

|      | 1987         | 1988         | 1989         |
|------|--------------|--------------|--------------|
| NSLC | \$280,828.9K | \$301,956.9K | \$334,580.7K |
| DESC | 213,876.6K   | 230,160.8K   | 255,494.5K   |

The detailed results are provided in Appendix G.

The models provide the PM with a simplified tool, however, the differences in the results are too great to accept each at face value. In these tests certain factors were not considered. The most readily observed problem is that both models combined annual costs with one-time

charges. For instance, annual costs for managing NSN's are combined with the one-time costs for provisioning. Furthermore, neither model considers the time value of money. Without a present value model, the PM does not have a means of comparing the 1987 acquisition outlays with 1994 logistics support costs. Thus, the numbers are not meaningful. The PM needs a simple tool that provides better costing information.

#### **D. STANDARDIZATION COSTING MODEL**

The following model incorporates the best elements of both models and provides a more complete, yet easy-to-use, tool. The goal of this model is to provide the manager with a methodology for evaluating the cost for adding a piece of new non-standard equipment to the fleet. Only costs resulting from the addition of non-standard equipment are considered. The model assumes that the workloads, e.g. maintenance and training, of both standard and non-standard equipment remain constant, and therefore those costs can be ignored. One-time costs are segregated from annual recurring charges so that the PM can estimate immediate impacts versus long-term affects. Furthermore it assumes a 10 year life expectancy to allow comparison with both the NSLC and DESC models.

The model incorporates the one-time (non-recurring) costs of:

- a. Provisioning
- b. Non-Standard Parts Drawing Documentation
- c. Testing
- d. Technical Manuals
- e. Installation Drawings
- f. Training Equipment
- g. Maintenance Aids (PMS Cards)

PTD is conspicuously absent in the model. As is explained in Appendix H, the computations for estimating the PTD costs require too many

assumptions that could cause the PM to question the credibility of the model. In addition, an argument can be made that the government already owns the drawings and does not need to pay for PTD. On the other hand, the equipment may be the manufacturer's own design and the government must pay for the complete package. In an effort to settle on a satisfactory middle ground the Non-Standard Parts Drawing Documentation element is included in the model.

The model also ignores the costs for adding a second source of supply. Once a second source has been added, the costs for maintaining the industrial base increases. The timeframe of the thesis precluded it, but the concept merits consideration.

The model also includes annual costs for:

- a. Stock Number Management
- b. Training Equipment Maintenance
- c. Configuration Control

Costs for organic and depot maintenance have been ignored since it is assumed that the equipment will require the same amount of maintenance as the items it replaced, and therefore costs are not unique.<sup>105</sup> The costs for additional procurement actions, price increases resulting from volume reductions, and additional storage and handling have also been omitted. These elements are unique to each equipment and the additional complexity would detract from the simplicity. With the exception of

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<sup>105</sup> In theory this may not be a valid assumption since maintenance requirements for new equipment "should" be less than the equipment it replaces.

training equipment maintenance, since each training pipeline differs, it is not possible to factor training costs.

The resulting model for non-recurring costs is:

$$\begin{aligned} & \{(MH)(\$/MH)[(.25P)/4](E)\} + \\ & \{450 + \{[300(NSP) + 75(SP)](E)\} + \{(\%PT)(\$/T)(NSP)(E)\} + \\ & \{62.5P + 20(Pop)\} + \{1,000(CL)\} + \{2PR\} + \{500\} \end{aligned}$$

and the model for annual costs is:

$$\{448(NSP)(E)\} + \{PR\} + \{20(BRF)(NSP)(E)\}$$

where MH is the number of manhours,  
 $\$/MH$  is the cost per MH,  
 P is the number of parts per equipment,  
 E is the number of new equipment,  
 NSP is the number of Non-Standard Parts,  
 SP is the number of Standardized Parts per each new equipment,  
 $\%PT$  is the percentage of parts tested,  
 $\$/T$  is the average cost per test,  
 Pop is the number of ships  
 CL is the number of different ship classes per installation,  
 PR is the equipment unit price, and  
 BRF is the Best Replacement Factor.

Using the above model with the APL/Parts Growth computed in Chapter III and a 10% discount rate, the projected costs for introducing non-standard equipment and parts during 1987-1989 are:

| Year | Non-Recurring Costs | Annual Costs | Life-Cycle Total Costs <sup>106</sup> |
|------|---------------------|--------------|---------------------------------------|
| 1987 | \$263,975.5K        | \$24,715.7K  | \$415,842.9K                          |
| 1988 | \$284,770.0K        | \$26,566.5K  | \$448,009.8K                          |
| 1989 | \$316,720.0K        | \$29,415.9K  | \$497,467.8K                          |

The potential costs resulting from non-standardization are substantial.

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<sup>106</sup> Non-Recurring and ten years of Annual Costs will not sum to Total Costs. Total Costs include the present value of the Annual Costs discounted 10% at the end of each year for 10 years.



Factoring a 5% inflation rate in the annual costs increases the Life-Cycle Total Costs to:

| Year | Life-Cycle<br>Total Savings |
|------|-----------------------------|
| 1987 | \$447,001.3K                |
| 1988 | \$481,476.1K                |
| 1989 | \$521,210.8K                |

The results of the Standardization Costing Model indicate that the NSLC and DESC models do not provide the manager with a picture of the total costs. If one accepts the assumptions of the Standardization Costing Model, then the decision by PM's to select nonstandard parts are causing significantly higher life cycle costs than the other models project.

Appendix H provides a detailed description of the model, and the computational results are presented in Appendix I. As an illustration, the projected costs for Pumps (CC 01) are:

| Year | Non-Recurring<br>Costs | Annual<br>Costs | Life-Cycle<br>Total Costs <sup>107</sup> |
|------|------------------------|-----------------|--|
| 1987 | \$ 13,026.8K           | \$ 1,238.1K     | \$ 20,633.9K                             |
| 1988 | \$ 13,678.1K           | \$ 1,299.9K     | \$ 21,665.6K                             |
| 1989 | \$ 14,362.0K           | \$ 1,364.9K     | \$ 22,748.9K                             |

The results of the model demonstrate that non-standardization is annually costing the Navy approximately a half billion dollars. If the other services experience the same situation, increased standardization provides DOD with a means of appeasing spending critics. In an era of reduced funding, especially highly vulnerable Operations and Maintenance, Navy (O&M,N) funds, as well as pressure to operate more efficiently,

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<sup>107</sup> Non-Recurring and Annual Costs will not sum to Total Costs. Total Costs include the present value of the Annual Costs discounted 10% for 10 years.

standardization can allow the service to improve readiness without sacrificing hardware or personnel.

The next logical step is to eliminate part duplication. As noted in Chapter III, there are potentially more than 29,000 duplicate parts in the Navy supply system and approximately another 2,000 entering annually through 1989. Assuming that the non-recurring costs for the parts currently in the system have already been absorbed, so that only annual charges are incurred, and employing the Standardization Costing Model to estimate the cost for duplicates now entering, the potential life-cycle savings are:

| Year    | Life-Cycle<br>Total Savings |
|---------|-----------------------------|
| Current | <u>\$18,828.7K</u>          |
| 1987    | 2,372.1K                    |
| 1988    | 2,521.7K                    |
| 1989    | 2,724.4K                    |

For instance, if the 29,268 potential duplicate parts estimated in Chapter III were eliminated, the total savings that the Navy could realize over the 10-year life cycle would be \$18,828.7K. Furthermore, if the estimated 1,968 potential duplicate parts entering the Navy supply system in 1987 are precluded from doing so, an additional \$2,372.1K could be saved over a 10-year life-cycle.

The savings through standardization and duplication reduction are not additive. The savings achieved by reducing duplicate parts are included in the savings achieved by parts standardization. However, the results demonstrate that reduction of non-standard parts can be achieved without paring equipment.

The projected savings do not include the personnel costs for identifying and reducing the duplicate population. Assuming that 10% of the savings will be used at \$30 per hour, the funds available could provide for a team of 30 to perform the work.<sup>108</sup> Obviously, such a large staff is not necessary.

#### E. PARTS AVAILABILITY

Savings achieved by reducing the inventory range do not improve Supply Material Availability (SMA) unless some of those monies are used to increase the depths of the standardized items. While beyond the scope of this thesis to compute an individual item's SMA improvement, it is possible to estimate the relative impact on the entire parts population if only a portion of the savings are re-invested. This is done by estimating the total number of units of each standardized part that can be added to inventory.

Computing the potential number of units required several assumptions. The cost per part was not available, so it was estimated by dividing the average equipment price by the average number of parts in each equipment. Since the average number of parts per APL is known, the potential inventory range was computed by multiplying the number of parts per APL by the total number of APL's at the end of 1986. Although it was recognized that not all items are stocked, this provided an adequate baseline for the remaining calculations. Using the assumption that 25% of

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<sup>108</sup> This calculation assumes that the average government employee earns \$30 per hour, including benefits, and is paid for 2,080 hours annually.

the parts in each APL are unique, the potential inventory range was reduced by 75% to estimate the range of different parts within each commodity class. This latter computation resulted in a range of 580,657, close to the estimated 600,000 managed by SPCC, thereby validating the calculations.<sup>109</sup>

In order to estimate the additional depths of parts, potential funds that could be generated through standardization and re-invested had to be estimated next. This required two calculations, one from savings achieved by reducing the annual operating expenses, and the other by reducing the non-recurring expenses.

Annual cost savings available for re-investment were first computed. It was assumed that 50% of the duplicate parts and 25% of the nonstandard parts would be eliminated. The savings achieved by these two reductions were then added to compute the initial amount of funds available from annual operating savings. To take into account the impacts of competition and increased volume, that value was then increased by 25% to estimate the potential purchasing power.

Similarly, savings available from reduction of non-recurring expenses were estimated. It was assumed that 25% of the equipment would be standardized, and those savings would be used for increasing inventory. These savings were also increased by 25% to compensate for the effects

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<sup>109</sup> The assumptions used in this paragraph were provided by NSLC. Interview with Mr. Richard Jones.

of competition to estimate the potential purchasing power generated by reduction of nonstandard equipment.

Finally, the potential total savings were divided by the sum of the cost per part multiplied by the inventory range to get the increase in average inventory depth for all parts. This procedure did not provide meaningful results, however, since it only computed an increase of .03 units per CC. As shown in Appendix J, very few classes had an increase of 1 or more parts per line item. Therefore, for the data to be meaningful it was aggregated by both annual and nonrecurring savings. Next, each sum was divided by the average cost per part to compute the average number of units that could be bought with the savings. Unlike the Standardization Costing Model, for ease of computation, estimates were for the first year of the life cycle, and not the remaining nine years, and thus time value of money was not a factor. These results were substantially more significant, and are provided in the following table:

| Year<br>Dup's | Annual<br>Funds<br>NA | Annual #<br>Parts<br>NA | Total<br>Funds | Total #<br>Parts |
|---------------|-----------------------|-------------------------|----------------|------------------|
| 1987          | \$ 8,464.9K           | 9,462                   | \$ 11,767.9K   | 13,154           |
| 1988          | 9,090.1K              | 9,677                   | 90,957.3K      | 101,672          |
| 1989          | 10,043.9K             | 10,183                  | 98,080.7K      | 104,414          |
|               |                       |                         | 109,018.8K     | 110,532          |

Intuitively with a depth increase of this magnitude, SMA can only improve, and with it, so does fleet readiness.

## F. TECHNICAL DATA COSTING

Throughout this thesis the importance of adequate technical documentation has been emphasized. However, Olson, Cunningham, and Wilkins noted that the costs for technical data could potentially offset the savings.<sup>110</sup> Therefore technical data must not be bought blindly; it requires business sense to determine when to buy it and how much to pay.

The PM must have a tool to aid in the decision of technical data viability. NSLC determined that the cost of data ownership was a function of:

- a. Population
- b. Unit Price
- c. Savings from Competition
- d. Obsolescence
- e. Interest Rate
- f. Equipment Complexity (i.e. the number of parts)
- g. Part Replacement Rate
- h. Testing and Tools
- i. System Life
- j. Technological State of the Art
- k. Potential for Commercial Applications

Using these elements, NSLC developed the Data Ownership Analysis model. It provides a basis for "measuring the potential savings achievable through full and open competition of all requirements throughout the life cycle of an equipment. The resultant model from this analysis provides a means to determine the threshold value up to which the

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<sup>110</sup> Edward J. Brost, A Comparative Analysis of Sole Source Versus Competitive Prices in the Acquisition of Weapon System Replenishment Spare Parts, Master's thesis, LSSR 51-82, Air Force Institute of Technology (AFIT), Wright-Patterson Air Force Base, Dayton, Ohio, September 1982, p 31-32, referencing Alan E. Olson, James A. Cunningham, and Donald J. Wilkins, A Cost-Benefit Analysis of Competitive Versus Sole-Source Procurement of Aircraft Replenishment Spare Parts, Master's Thesis, SLSR 21-74A, AFIT, January 1974.

Government should be willing to pay for remanufacturing quality data with some probability of savings."<sup>111</sup> Based on the model, if the potential savings are equal to or exceed the cost of the data, then it is cost effective to buy the technical data.

To demonstrate the potential cost savings per commodity class would not provide useful information within the context of this thesis because the assumptions required to calculate the costs across the equipment spectrum are too broad to fit the individual items and would invalidate any results. However, the model does provide the PM with a useful tool, and for that reason, is presented in Appendix K.

#### G. CHAPTER SUMMARY

The manager needs a simple tool for determining the life cycle costs of fielding non-standard equipment. Two current models were evaluated. The DESC model, the more conservative of the two, projected the 1989 cost for non-standardization to be more than \$250M. However, the differences between the two models were significant, and neither considered all factors. Thus, the Standardization Costing Model was proposed. This model incorporated cost elements of both the NSLC and DESC models as well as other factors, such as the time value of money, that those two models ignored. Using the same data, the Standardization Costing Model projected costs of more than \$521M. Unlike the NSLC and DESC models, the Standardization Costing Model includes all the costs for

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<sup>111</sup> Mr. Richard Jones, H,M&E Standardization.

non-standardization and provides the PM with a picture of the total life cycle costs.

The potential savings are therefore substantial. Injecting part of these funds back into inventory are estimated to increase the repair parts population depth by more than 100,000 units per year. An increase of this magnitude, if wisely invested, can only improve fleet readiness.



## **V. SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS**

### **A. INTRODUCTION**

The subsidiary research questions were examined in detail in Chapters 2 through 4. In this chapter, the answers to these questions are summarized with appending conclusions. The primary research question is then addressed, and recommendations for improving management of non-standard items are offered. The chapter concludes with several areas meriting additional research.

### **B. RESEARCH QUESTIONS**

Question 1. What is the relationship between the acquisition process and standardization of equipment and parts?

The introduction of new equipment is governed by a myriad of OMB, FAR, and DOD regulations, instructions, and directives. The primary consideration of the guidance is deployment of new technology to meet the immediate threat. Long term supportability is only a secondary issue.

System supportability is one of the factors that the PM must consider when evaluating system trade-offs. OMB Circular A-109 and DOD Directive 5000.1 require consideration of life-cycle costs as a part of the PM's decision process, but don't provide the manager with any guidelines.

Consideration of non-standard parts does not appear to be a major issue in the DSARC process. However, recently guidance have been provided to control parts proliferation. Unfortunately, nothing forces the PM to support standardization. In fact, the PM can override the

recommendations provided by Military Parts Control Advisory Groups (MPCAG) and the Departmental Standardization Officer (DepSO).

Conclusion. DOD already has the capability to control entry of non-standard parts into the system, but it does not provide any responsibility or authority to organizations which can enforce standardization. For example, if part proliferation is to be controlled, the DSARC process must give more consideration to life-cycle support issues. However, until the PM's are given the tools to facilitate making such decisions, restrictions cannot be imposed. The PM is held accountable for all his/her decisions and should not be thwarted by a bureaucratic process that does not understand the project. The DOD organization must not be an impediment to a much needed weapon system. Once the PM has the tools, then a total assessment is not only prudent, but should be evaluated during DSARC.

Question #2. How has the lack of technical documentation caused inventory ranges to expand?

Technical data needed for standardization of parts is expensive. Thus, it is not unusual for PM's to delay data procurement in order to spend the project's limited funds on hardware development. Items lacking technical data will be assigned NSN's, even if a duplicate exists, because the Defense Logistics Supply Center (DLSC) does not have the capability to compare the part with current inventory. A change in the Federal Supply Code for Manufacturers (FSCM) or Part Number (P/N) is all that is needed. The problem has been exacerbated by the lack of information available to cross check submissions. DLSC is addressing this issue but, in the meantime, the inventory ranges increase.

Conclusion. The technical data is needed to effect standardization. However, the decision to procure technical data must be based on life-cycle effectiveness. From the fleets' perspective, the onus is on the supply system to provide support even though the PM failed to purchase adequate documentation. If the PM decides against procuring the data, then the supply system should require that the PM annually provide funds for inventory support. The costs may be sufficient to force the manager to reconsider the decision. If the annual costs are expected to be insignificant and the impact on readiness inconsequential, then it was a sound business decision not to purchase data.

Question #3. How does Navy policy affect inventory standardization?

Navy policy clearly supports the goals of standardization. Yet, until recently, NAVSEA specifically excluded the shipbuilding program from standardization requirements. As a result, 40% of all the Navy's non-standard parts were generated during new construction.

NAVSEA has finally taken the first step to reduce proliferation by requiring adherence to the DOD Parts Control Program (PCP). It may take the organization's bureaucracy awhile to change direction, but NAVSEA has placed increased attention on the issue.

The issue of incentives as a means to encourage industry to increase use of standard parts has never been fully explored. A relatively insignificant attempt on the USS EISENHOWER contract did not provide Newport News Shipbuilding with a meaningful incentive.

Engineers are not provided with the capability for rapidly screening DOD inventories for common parts. The engineers must manually search microfiche copies of the NAVSEA Standard Component List (NSCL) and the Master Index of Allowance Parts Lists (MIAPL). The Technical Logistics Reference Network (TLRN) is slow and can take upwards of 5 hours to search for a part. DLA is developing a system that searches for a part based on 10 characteristics and averages 9.5 minutes per part. However, the engineer frequently needs more than the 10 character limit in order to fully identify the equipment requirements. DLA does not have plans to install the system at the working level.

In a procurement the use of performance (form, fit, and function) as the sole criteria adds to part proliferation while reducing standardization. The criteria is intended, however, to stimulate competition. If the procurement is not administered wisely, the costs of non-standardization can far outweigh the savings generated from the competition.

Conclusion. Acceptance of the standardization program can be accelerated by establishing standardization goals for PM's and Naval Ship Yard (NSY) Commanders. Additional emphasis must be also placed on increased incentives for the contractor. However, until the engineers are provided with adequate tools to aid in the parts selection process, incentives will be an ineffective method for increasing standardization. NAVSEA Logistics Center (NSLC) has made great strides to provide the tool. Unfortunately, DLA does not have any intention on providing the designer with access capability to the CSS. With pressure to meet the tight schedules and emphasis on increasing productivity, engineers can be

expected to continue to follow the path of least resistance by opting for readily identifiable non-standard parts.

Question #4. What are the potential impacts of non-standardization on the Navy's inventory levels?

Based on the tables in Chapter III, the annual number of non-standard equipment deploying is expected to increase to approximately 11,500 by 1989. This, in turn, results in an annual spare and repair parts growth of more than 42,000 by 1989.

Conclusion. As annual appropriations tighten, the funds for depth that should be purchased are being diverted to support the added range. Consequently, weapon systems may not receive adequate support. Unfortunately, all systems will be affected, not just the ones where the PM discounted standardization efforts.

Question #5. What is being done to implement standardization?

The Navy has several ongoing standardization programs. The 2-Inch and Under Valve project is expected to save the Navy over \$700M dollars over the life of the equipment. Shortly, standardization of the P-250 Fire Pump and the Titanium Fire Pump will be completed with similar expectations. As a result of the reduction in the range of parts, it is anticipated that material support will significantly improve.

Conclusion. The savings along with the improved material support only lends further support to the arguments for standardization. The conclusion is self-explanatory; the efforts must continue.

Question #6. What standardization costing models are available as tools in the decision process?

If the PM is going to accept a costing model as a decision tool, then it must be simple and reliable. At the present, two models provide this, one from NSLC and another from DESC. AIAA has also developed a model, but it is far too complex to be practical and is more applicable to decisions concerning standardization of non-standard parts already in inventory.

Unfortunately, the NSLC and DESC models do not consider all costs. Both ignore the time value of money, thereby overstating the life-cycle costs. The NSLC model does not include the one-time charges for documentation and testing. Technical manuals, training equipment, maintenance aids, and configuration control are not considered by the DESC model. Therefore, a Standardization Costing Model that incorporates features from all three models (including AIAA's) was proposed. It is a simplified model that provides the PM with a more complete picture of the life-cycle costs.

Conclusion. The PM has two tools available, but, if parts proliferation is a reliable indicator, obtaining wide-spread acceptance of the models has been less than outstanding. Efforts have been undertaken recently at NAVSEA to incorporate the NSLC model into the planning process.<sup>112</sup> The Standardization Costing Model proposed in this thesis

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<sup>112</sup> Commander, Naval Sea Systems Command, Use of Total Cost Concept to Determine Performance Specification Assemblies Breakout Candidates, Letter to Commander, Naval Supply Systems Command (PML-550), 4408 OPR:CEL-MS2 Ser CEL-MS/4080, 18 May 1987.

provides an alternative. It combines simplicity with greater life-cycle cost visibility, and should be considered by the program manager.

Question #7. What are the costs and impacts of non-standardization?

Using the Standardization Costing Model developed in Chapter IV, life cycle costs resulting from continued introduction of non-standard parts will increase from \$415.8M in 1987 to 497.5M in 1989. If a 5% inflation rate is factored in the computation, then the costs change to \$447.0M in 1987 and \$521.2M in 1989.

If a freeze on new non-standard parts is imposed, only 69% of the potential savings could be immediately realized. The remaining savings would accrue over the next several years.

It is difficult to assess the impact on Supply Material Availability (SMA) if the savings from a non-standard part freeze are re-invested in depth. However, by 1989, the expected savings could provide every ship in the KIDD (DDG-993) class with a depth increase of 1 for every authorized part.

Conclusion. The projected costs of non-standardization are astronomical. If the assumptions used to develop the model are acceptable, then savings from standardization can both increase inventory depth, and reduce logistics costs and operating expenses. Fleet readiness will be the ultimate benefactor.

## C. RECOMMENDATIONS

The remainder of this chapter is devoted to the primary research question: How can the Navy improve management of non-standard inventory? The recommendations are oriented towards two separate parties:

1. Navy Supply Systems activities, and
2. Policy setting organizations.

1. Supply System Recommendations

Improved SMA, and hence fleet readiness, is the primary issue addressed by this section. The secondary issue, considered in conjunction with the primary goal, is cost reduction.

To resolve these issues requires a four-step approach. The first step is reduction of duplicate parts already in the system. The second is identification of similar parts that lend themselves to consolidation. The third step is re-investment of savings for increased depth, and the fourth is education to sustain the standardization effort.

The fastest way to reduce the range is through elimination of duplicate parts. This elimination enables the supply system to invest more monies in the remaining inventory. The NSLC CCF Modernization project, when completed, will provide the capability to rapidly screen the data base and hence improve identification of existing parts during the design phase.

The next step is consolidation of items that have similar characteristics but are not identical. It encompasses identification of parts with high failure rates (BRF's) and low population. An arbitrary starting point would be with parts that have a BRF of 50% or more, are



used on five or fewer platforms, and which 75% of the characteristics are identical.<sup>113</sup> A fourth decision parameter may be parts that have experienced a C-3 or C-4 Casualty Report (CASREPT) within the past year or which have the potential for causing a CASREPT. As the parts are identified, decisions to redesign parts or equipment for substitutability or interchangeability (S/I) should be made with the consent of the Hardware Systems Command (HSC). It is the responsibility of the HSC to assess the impact on mission performance that such a change may cause.

The AIAA model provided in Chapter IV can assist with the decision to redesign the part. It provides the engineer, logistician, and HSC a tool for comparing cost savings for standardizing the parts. The costs can then be compared with potential for improved SMA allowing the PM to make an informed decision. Again, the NSLC CCF project, when completed, will permit the engineer to screen the SPCC data base for the applicable parts.

Potential cost savings should be a criterion in determining which items to consolidate. However, it should be pointed out that costs are of secondary concern; SMA is the primary issue. The analysis recommended above can begin in the areas where savings potential are greatest. This enables the engineer to concentrate on effectiveness while exacting the greatest return in savings.

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<sup>113</sup> The selection of a 50% BRF was strictly arbitrary. The value for 5 ships was selected since over 73% of the APL's are found on 5 or fewer ships.

The timing of a reduction in range should coincide with an increase in depth. This can only transpire if the funds saved are quickly made available for re-investment.<sup>114</sup> Unfortunately, the potential savings forecast in Chapter IV are funds from different sources (e.g. O&M,N, NSF, WPN, and OPN). It will take the concurrence of the individual weapon system sponsors to "trade" for the applicable appropriations.

Finally, it is essential that an educational program be undertaken so that managers in headquarters activities fully comprehend the detrimental effects of non-standardization and the savings which can result from standardization. Only with the concurrence and, most importantly, the sustained support of the decision makers, will the benefits of standardization be realized.

## 2. Other Recommendations

Resolving the problem of non-standardization requires support from all echelons, from Secretariat to the HSC level to the supply system. Once support is garnered from the top, then it is likely that everyone else will fall in line.

A proponent must be established within SECNAV, and it is appropriate to assign the responsibility to the Competition Advocate's Office (CAO). The wherewithal is available as the CAO already

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<sup>114</sup> Reduction of part range without an increase in depth is essentially nothing more than elimination of inventory without replenishment. As non-standard items are issued, replacement orders are not placed and, as such, fewer requisitions can be satisfied from on hand inventory.

reviews specifications. It is a natural extension and it allows the office to operate in a business strategy role.

Throughout the thesis it has been noted that while programs have been established they are often not fully supported financially. One of the reasons has been the standards offices' lack of authority with respect to acquisition decisions. This can quickly be alleviated by providing the CAO with "control of the purse strings." As acquisition strategies of the individual projects are reviewed, standardization efforts can be assessed. If the program is unsatisfactory, then funding can be withheld. In this manner, the PM still has the authority to reject the MPCAG's recommendation, but the PM must persuade the CAO that it was a wise decision.

An alternative is to make the MPCAG and standards offices' recommendations a part of the DSARC/SSARC process. During milestone reviews, the PM would then address the project's standardization efforts. This must begin with the very first review since once approval is given to Full Scale Engineering and Development (FSED) it becomes too costly to change a non-standard part to a standard one.

The HSC's also need to provide their internal standards programs with increased authority and an appropriate mission. Currently, the role of the NAVSEA Standardization Office is to review specifications rather than initiate programs. Goals are set based on the number of specifications reviewed and brought up to date. It is work that must be done but the goal reenforces a relatively ineffective program. Priorities

of the NAVSEA Office can be reset by establishing a goal for savings (not a percentage, but actual dollar values) rather than workload. In this manner then the office can take a proactive role.

Once the mission is redefined, then the offices will have the ability to assist PM's in standardization efforts. Furthermore, they can play a role similar to the CAO. PM's are always looking for additional monies. By providing the Command Standardization Officer (ComSO) with a portion of the HSC's budget, the ComSO can fund individual project's standardization programs offering the greatest return. It not only gives the ComSO more authority, but also offers the PM another incentive to use standard parts.

#### **D. FUTURE RESEARCH**

This thesis has presented a preliminary evaluation of Navy related problems caused by non-standard parts. In the course of this evaluation many areas surfaced that offered potential for further research.

All thesis research concentrated on Department of Defense and Navy problems. There is also a vast amount of experience outside the government, and DOD can learn from the standardization lessons of companies such as Ford, American Airlines, and Sears. Many of their lessons can be readily applied to the supply system.

The Standardization Costing Model used many assumptions, some necessarily arbitrary. For instance the costs for configuration control were based on experience rather than substantive data. The intent of the model was not to perfectly predict the costs for non-standardization, but

rather to provide the PM with a decision-making tool. The assumptions used must be validated. Once that is completed, then the model should be microscopically examined to ensure that it is not overlooking an important variable. In this manner the PM can be assured that the model is an effective tool.

The thesis was written from the perspective of a logistician and, as such, issues that appear to be problems may not be viewed the same way by the PM. The PM has many other problems, all clamoring for attention. Issues such as standardization may not receive the same priority an inventory oriented person may give it. The views of the PM must be addressed if this issue is to be completely understood.

One of the goals of this thesis was that it would form the basis for a central reference source. It has accomplished this goal, but there is much more to standardization than inventory. Training programs, technical manuals, maintenance procedures, and intermediate and depot level repair programs are also affected by the lack of commonalty. For all involved to fully understand the issue of standardization, a future undertaking must address these areas.

## **APPENDIX A : APL AND PARTS GROWTH DATA**

Appendix A summarizes the data used to develop the APL and Parts Growth estimates and the results of the model. Data for the Ship Population table, A.1, was provided by Chief of Naval Operations, OP-90K. NSLC supplied the information from the WSF for the APL Data table, A.2. The data for A.2 is presented in two parts since not all data could be printed on one page. The APL Statistical Summary table, A.3, provides the statistics and regression analysis results used in estimating APL growth for each commodity class. Numbers enclosed in parentheses ( ) denote negative values. Table A.3 is also presented in two parts. The final table, APL and Part Growth Results, A.4, shows the growth of equipment and parts by each commodity class.

# A.1 Ship Population

| Nomenclature | 1977 | 1978 | 1979 | 1980 | 1981 | 1982 | 1983 |
|--------------|------|------|------|------|------|------|------|
| Total Ships  | 477  | 468  | 473  | 488  | 491  | 514  | 514  |
| Deliveries   | 14   | 15   | 11   | 12   | 15   | 25   | 18   |
|              | 1984 | 1985 | 1986 | 1987 | 1988 | 1989 |      |
| Total Ships  | 524  | 545  | 555  | 569  | 582  | 605  |      |
| Deliveries   | 15   | 16   | 11   | 13   | 8    | 19   |      |

## A.2 APL Data

| Nomenclature       | Commodity |  | 1977 | 1978 | 1979 | 1980 | 1981 | 1982  | 1983 | 1984 |
|--------------------|-----------|--|------|------|------|------|------|-------|------|------|
|                    | Class     |  |      |      |      |      |      |       |      |      |
| PUMPS              | 1         |  | 272  | 365  | 211  | 222  | 173  | 381   | 403  | 610  |
| BOILERS            | 2         |  | 7    | 7    | 5    | 15   | 5    | 6     | 3    | 12   |
| HEAT EXCHANGERS    | 3         |  | 50   | 56   | 37   | 30   | 34   | 56    | 52   | 65   |
| CONDENSERS         | 4         |  | 12   | 10   | 11   | 12   | 6    | 13    | 3    | 12   |
| TURBINES           | 5         |  | 21   | 14   | 14   | 13   | 14   | 26    | 12   | 15   |
| COMPRESSORS        | 6         |  | 37   | 46   | 37   | 32   | 24   | 54    | 35   | 66   |
| HEATERS            | 7         |  | 208  | 189  | 155  | 115  | 142  | 188   | 130  | 122  |
| DISTILLING PLANTS  | 8         |  | 12   | 10   | 6    | 3    | 6    | 15    | 10   | 9    |
| BATTERY CHARGERS   | 9         |  | 13   | 3    | 18   | 16   | 16   | 19    | 24   | 44   |
| METERS             | 10        |  | 14   | 15   | 10   | 12   | 11   | 29    | 13   | 20   |
| CONVERTERS         | 11        |  | 15   | 16   | 16   | 53   | 15   | 33    | 37   | 37   |
| TRANSFORMERS       | 13        |  | 0    | 0    | 5    | 37   | 15   | 5     | 4    | 3    |
| CIRCUIT BREAKERS   | 14        |  | 183  | 131  | 110  | 186  | 69   | 146   | 115  | 125  |
| CONTROLLERS        | 15        |  | 408  | 246  | 225  | 308  | 277  | 518   | 446  | 573  |
| GENERATORS         | 16        |  | 10   | 25   | 24   | 25   | 24   | 90    | 58   | 75   |
| MOTORS             | 17        |  | 563  | 579  | 331  | 468  | 558  | 1,097 | 306  | 339  |
| MOTOR GENERATORS   | 18        |  | 3    | 5    | 6    | 4    | 4    | 11    | 3    | 13   |
| RELAYS             | 19        |  | 33   | 29   | 49   | 172  | 41   | 55    | 48   | 27   |
| RHEOSTATS          | 20        |  | 2    | 1    | 2    | 9    | 3    | 9     | 3    | 3    |
| SWITCHES           | 21        |  | 190  | 173  | 181  | 180  | 174  | 323   | 292  | 222  |
| SWITCHBOARDS       | 22        |  | 56   | 53   | 56   | 66   | 32   | 53    | 101  | 66   |
| VISUAL ALARMS      | 23        |  | 5    | 5    | 8    | 3    | 3    | 23    | 20   | 17   |
| LIGHTING FIXTURES  | 24        |  | 9    | 15   | 5    | 15   | 10   | 33    | 50   | 41   |
| GYRO COMPASSES     | 25        |  | 10   | 22   | 17   | 13   | 6    | 40    | 33   | 14   |
| PROJECTION EQUIP   | 26        |  | 0    | 1    | 0    | 1    | 0    | 1     | 1    | 5    |
| I/C EQUIP          | 27        |  | 29   | 54   | 30   | 55   | 27   | 68    | 78   | 35   |
| NAVIGATIONAL EQUIP | 28        |  | 2    | 4    | 14   | 2    | 5    | 18    | 10   | 24   |
| INJECTORS          | 29        |  | 0    | 4    | 1    | 2    | 0    | 2     | 1    | 2    |
| BURNERS            | 30        |  | 7    | 5    | 1    | 0    | 7    | 2     | 3    | 7    |
| MARINE HARDWARE    | 31        |  | 36   | 32   | 45   | 24   | 13   | 27    | 32   | 68   |
| REFRIG EQUIP       | 32        |  | 175  | 192  | 176  | 166  | 109  | 321   | 345  | 337  |
| AIR CONDITIONING   | 33        |  | 32   | 19   | 42   | 10   | 25   | 19    | 27   | 25   |
| STARTERS           | 34        |  | 12   | 9    | 5    | 8    | 1    | 13    | 3    | 17   |
| WIPERS             | 35        |  | 5    | 14   | 2    | 4    | 3    | 3     | 5    | 3    |
| AUDIBLE ALARMS     | 36        |  | 1    | 1    | 5    | 6    | 1    | 9     | 9    | 9    |
| BEARINGS           | 37        |  | 2    | 7    | 14   | 3    | 3    | 14    | 14   | 11   |
| INDICATORS         | 38        |  | 32   | 95   | 126  | 74   | 97   | 116   | 142  | 133  |
| CLUTCHES           | 39        |  | 3    | 3    | 1    | 3    | 11   | 3     | 9    | 13   |
| FANS               | 40        |  | 30   | 55   | 20   | 128  | 89   | 34    | 11   | 10   |
| CHOP EQUIP         | 41        |  | 169  | 138  | 133  | 30   | 130  | 217   | 118  | 189  |
| REGULATORS         | 42        |  | 13   | 14   | 13   | 23   | 3    | 21    | 16   | 25   |
| GALLEY EQUIP       | 43        |  | 75   | 111  | 91   | 67   | 100  | 208   | 200  | 180  |
| DEHYDRATORS        | 44        |  | 3    | 12   | 3    | 3    | 6    | 11    | 11   | 14   |
| GAGES              | 45        |  | 73   | 124  | 95   | 65   | 71   | 112   | 186  | 138  |
| TESTING EQUIP      | 46        |  | 22   | 27   | 29   | 26   | 240  | 69    | 59   | 46   |
| FILTERS            | 48        |  | 158  | 134  | 133  | 144  | 78   | 193   | 189  | 178  |
| PANELS             | 50        |  | 124  | 176  | 130  | 229  | 333  | 171   | 271  | 190  |



## A.2 APL Data

| Nomenclature           | Commodity |       | 1977  | 1978  | 1979  | 1980  | 1981  | 1982  | 1983  | 1984  |
|------------------------|-----------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
|                        | Class     |       |       |       |       |       |       |       |       |       |
| ISOLATORS              | 51        | 1     | 0     | 0     | 0     | 0     | 0     | 0     | 0     | 1     |
| HYDRALIC EQUIP         | 52        | 35    | 47    | 25    | 28    | 17    | 32    | 31    | 83    |       |
| CAPSTANS               | 53        | 3     | 2     | 2     | 4     | 3     | 6     | 5     | 3     |       |
| REELS                  | 55        | 11    | 11    | 6     | 13    | 4     | 20    | 27    | 21    |       |
| DAVITS                 | 56        | 3     | 1     | 3     | 1     | 0     | 7     | 7     | 3     |       |
| CRANES                 | 57        | 28    | 9     | 4     | 30    | 0     | 10    | 3     | 3     |       |
| HOISTS                 | 58        | 46    | 46    | 17    | 28    | 17    | 20    | 34    | 37    |       |
| ELEVATORS              | 59        | 21    | 7     | 18    | 25    | 4     | 13    | 5     | 8     |       |
| STEERING EQUIP         | 60        | 1     | 3     | 0     | 2     | 1     | 5     | 5     | 2     |       |
| CONTROL EQUIP          | 61        | 175   | 244   | 328   | 363   | 334   | 315   | 318   | 369   |       |
| WINCHES                | 62        | 14    | 18    | 15    | 5     | 7     | 33    | 35    | 37    |       |
| WINDLASSES             | 63        | 3     | 4     | 4     | 4     | 1     | 5     | 3     | 6     |       |
| FIREFIGHTING EQUIP     | 64        | 39    | 31    | 20    | 27    | 30    | 52    | 59    | 35    |       |
| LUBRICATORS            | 65        | 10    | 15    | 12    | 6     | 7     | 12    | 18    | 17    |       |
| ENGINES                | 66        | 34    | 30    | 33    | 28    | 25    | 36    | 35    | 45    |       |
| PLUMBING EQUIP         | 67        | 3     | 13    | 8     | 11    | 5     | 13    | 15    | 3     |       |
| GEARS AND REDUCERS     | 69        | 44    | 47    | 18    | 46    | 31    | 35    | 43    | 75    |       |
| GOVERNORS              | 70        | 14    | 4     | 12    | 6     | 8     | 33    | 20    | 35    |       |
| IGNITION EQUIP         | 71        | 0     | 0     | 1     | 0     | 0     | 0     | 0     | 0     |       |
| EJECTORS               | 73        | 10    | 5     | 2     | 2     | 2     | 4     | 4     | 4     |       |
| EDUCTORS               | 74        | 0     | 0     | 0     | 0     | 0     | 2     | 2     | 3     |       |
| STRAINERS              | 75        | 37    | 196   | 30    | 30    | 79    | 102   | 54    | 123   |       |
| PURIFIERS              | 76        | 26    | 12    | 5     | 4     | 9     | 21    | 16    | 19    |       |
| TRAPS-STEAM            | 77        | 12    | 16    | 16    | 10    | 7     | 14    | 8     | 13    |       |
| COUPLINGS              | 78        | 14    | 23    | 10    | 30    | 14    | 47    | 37    | 42    |       |
| SILENCING EQUIP        | 79        | 0     | 2     | 4     | 0     | 4     | 11    | 5     | 6     |       |
| BRAKES                 | 80        | 19    | 23    | 12    | 55    | 22    | 26    | 44    | 39    |       |
| BLOWERS                | 81        | 22    | 8     | 10    | 16    | 10    | 4     | 3     | 6     |       |
| WELDING SYSTEMS        | 82        | 22    | 26    | 7     | 11    | 16    | 34    | 39    | 37    |       |
| BOAT PROPULSION        | 83        | 18    | 12    | 20    | 21    | 22    | 31    | 16    | 30    |       |
| DECK MACHINERY         | 85        | 69    | 55    | 63    | 41    | 43    | 69    | 65    | 13    |       |
| PHOTOGRAPHIC EQUIP     | 86        | 1     | 1     | 2     | 1     | 1     | 0     | 2     | 3     |       |
| UNDERWATER LOG EQUIP   | 87        | 2     | 1     | 3     | 1     | 1     | 0     | 0     | 2     |       |
| VALVES                 | 88        | 1,598 | 2,458 | 1,391 | 1,961 | 1,371 | 2,051 | 1,289 | 1,379 |       |
| MISC PARTS             | 89        | 60    | 107   | 396   | 166   | 106   | 47    | 533   | 461   |       |
| LAUNDRY EQUIP          | 91        | 38    | 28    | 27    | 25    | 29    | 109   | 64    | 75    |       |
| TANKS                  | 92        | 24    | 3     | 5     | 17    | 16    | 26    | 27    | 27    |       |
| PIPE, HOSE, & FITTINGS | 93        | 2     | 3     | 6     | 9     | 0     | 4     | 1     | 4     |       |
| ASW EQUIP              | 94        | 0     | 3     | 6     | 0     | 0     | 6     | 1     | 16    |       |
| YELLOW GEAR            | 95        | 1,224 | 1,013 | 1,009 | 1,358 | 1,162 | 1,193 | 1,555 | 921   |       |
| PERISCOPES             | 97        | 13    | 16    | 11    | 0     | 0     | 5     | 1     | 2     |       |
| MISC EQUIP             | 99        | 28    | 56    | 25    | 68    | 17    | 43    | 31    | 71    |       |
| GRAND TOTALS           |           |       | 7,011 | 7,367 | 7,370 | 7,662 | 6,353 | 9,426 | 9,399 | 8,952 |

## A.2 APL Data

| Nomenclature       | 1985  | 1986  | Total<br>APL's | 1983 Ave<br>Equip Price | Fleet<br>Population |
|--------------------|-------|-------|----------------|-------------------------|---------------------|
| PUMPS              | 448   | 555   | 7,400          | 8,357                   | 118,070             |
| BOILERS            | 7     | 11    | 198            | 17,898                  | 1,525               |
| HEAT EXCHANGERS    | 94    | 95    | 1,675          | 6,846                   | 30,242              |
| CONDENSERS         | 8     | 15    | 797            | 8,492                   | 7,354               |
| TURBINES           | 22    | 39    | 905            | 124,067                 | 11,769              |
| COMPRESSORS        | 62    | 76    | 808            | 18,298                  | 12,943              |
| HEATERS            | 242   | 226   | 2,523          | 1,042                   | 97,449              |
| DISTILLING PLANTS  | 11    | 10    | 320            | 15,429                  | 3,473               |
| BATTERY CHARGERS   | 40    | 49    | 290            | 3,339                   | 5,188               |
| METERS             | 43    | 41    | 439            | 2,664                   | 8,081               |
| CONVERTERS         | 38    | 55    | 657            | 8,254                   | 15,116              |
| TRANSFORMERS       | 5     | 8     | 878            | 388                     | 102,412             |
| CIRCUIT BREAKERS   | 231   | 203   | 3,971          | 276                     | 887,373             |
| CONTROLLERS        | 765   | 819   | 11,912         | 494                     | 159,326             |
| GENERATORS         | 53    | 65    | 704            | 75,291                  | 10,273              |
| MOTORS             | 1,038 | 1,025 | 14,014         | 3,433                   | 177,056             |
| MOTOR GENERATORS   | 11    | 9     | 351            | 25,366                  | 3,094               |
| RELAYS             | 36    | 58    | 1,543          | 213                     | 92,811              |
| RHEOSTATS          | 16    | 4     | 509            | 657                     | 3,050               |
| SWITCHES           | 376   | 469   | 9,260          | 403                     | 1,039,502           |
| SWITCHBOARDS       | 133   | 116   | 2,839          | 7,218                   | 16,058              |
| VISUAL ALARMS      | 14    | 66    | 515            | 489                     | 273,672             |
| LIGHTING FIXTURES  | 28    | 36    | 1,035          | 115                     | 1,404,922           |
| GYRO COMPASSES     | 12    | 33    | 806            | 5,863                   | 23,541              |
| PROJECTION EQUIP   | 1     | 4     | 54             | 0                       | 3,753               |
| I/C EQUIP          | 38    | 47    | 1,286          | 2,429                   | 266,648             |
| NAVIGATIONAL EQUIP | 25    | 41    | 322            | 422                     | 9,447               |
| INJECTORS          | 9     | 11    | 71             | 1,552                   | 31,610              |
| BURNERS            | 10    | 8     | 109            | 14,362                  | 4,509               |
| MARINE HARDWARE    | 44    | 77    | 1,573          | 1,375                   | 41,252              |
| REFRIG EQUIP       | 339   | 390   | 3,407          | 9,527                   | 62,866              |
| AIR CONDITIONING   | 32    | 27    | 206            | 3,442                   | 4,747               |
| STARTERS           | 32    | 29    | 216            | 7,394                   | 4,512               |
| WIPERS             | 5     | 8     | 178            | 61                      | 11,301              |
| AUDIBLE ALARMS     | 6     | 16    | 99             | 5,857                   | 1,006               |
| BEARINGS           | 13    | 19    | 632            | 14,606                  | 11,126              |
| INDICATORS         | 138   | 276   | 2,192          | 1,318                   | 98,042              |
| CLUTCHES           | 7     | 10    | 146            | 29,547                  | 3,134               |
| FANS               | 136   | 161   | 2,292          | 2,389                   | 32,019              |
| SHOP EQUIP         | 238   | 174   | 3,208          | 1,245                   | 21,365              |
| REGULATORS         | 29    | 24    | 884            | 1,169                   | 15,603              |
| GALLEY EQUIP       | 206   | 222   | 2,142          | 6,441                   | 30,416              |
| DEHYDRATORS        | 14    | 13    | 247            | 16,455                  | 4,629               |
| GAGES              | 92    | 122   | 3,252          | 1,303                   | 56,000              |
| TESTING EQUIP      | 63    | 98    | 637            | 2,262                   | 17,445              |
| FILTERS            | 240   | 192   | 3,563          | 1,903                   | 131,577             |
| PANELS             | 242   | 376   | 4,265          | 1,908                   | 81,303              |

## A.2 APL Data

| Nomenclature           | 1985   | 1986   | Total<br>APL's | 1983 Ave<br>Equip Price | Fleet<br>Population |
|------------------------|--------|--------|----------------|-------------------------|---------------------|
| ISOLATORS              | 1      | 0      | 20             | 4,836                   | 986                 |
| HYDRALIC EQUIP         | 184    | 200    | 1,368          | 31,718                  | 21,550              |
| CAPSTANS               | 6      | 5      | 140            | 27,236                  | 1,059               |
| REELS                  | 28     | 25     | 306            | 2,270                   | 8,290               |
| DAVITS                 | 2      | 12     | 191            | 14,065                  | 1,001               |
| CRANES                 | 10     | 14     | 307            | 91,520                  | 1,295               |
| HOISTS                 | 45     | 63     | 717            | 2,616                   | 4,551               |
| ELEVATORS              | 13     | 9      | 740            | 6,310                   | 4,759               |
| STEERING EQUIP         | 4      | 10     | 132            | 0                       | 683                 |
| CONTROL EQUIP          | 479    | 463    | 6,785          | 972                     | 350,227             |
| WINCHES                | 34     | 63     | 742            | 27,930                  | 5,740               |
| WINDLASSES             | 3      | 2      | 162            | 20,595                  | 872                 |
| FIREFIGHTING EQUIP     | 92     | 60     | 345            | 2,661                   | 74,092              |
| LUBRICATORS            | 14     | 8      | 253            | 1,110                   | 3,458               |
| ENGINES                | 95     | 57     | 506            | 62,971                  | 6,777               |
| PLUMBING EQUIP         | 9      | 20     | 259            | 0                       | 70,414              |
| GEARS AND REDUCERS     | 79     | 83     | 1,349          | 37,715                  | 18,731              |
| GOVERNORS              | 50     | 38     | 390            | 10,515                  | 6,511               |
| IGNITION EQUIP         | 0      | 1      | 4              | 2,880                   | 712                 |
| EJECTORS               | 4      | 7      | 415            | 9,653                   | 4,046               |
| EDUCTORS               | 4      | 6      | 369            | 2,684                   | 5,939               |
| STRAINERS              | 31     | 170    | 4,191          | 92                      | 147,395             |
| PURIFIERS              | 27     | 47     | 267            | 18,078                  | 4,996               |
| TRAPS-STEAM            | 24     | 13     | 1,014          | 314                     | 117,576             |
| COUPLINGS              | 72     | 66     | 942            | 14,574                  | 46,510              |
| SILENCING EQUIP        | 11     | 1      | 161            | 682                     | 2,680               |
| BRAKES                 | 37     | 57     | 828            | 1,729                   | 8,997               |
| BLOWERS                | 5      | 6      | 240            | 8,061                   | 7,279               |
| WELDING SYSTEMS        | 33     | 47     | 367            | 0                       | 3,376               |
| BOAT PROPULSION        | 23     | 64     | 909            | 40,504                  | 7,528               |
| DECK MACHINERY         | 22     | 41     | 1,663          | 3,520                   | 31,590              |
| PHOTOGRAPHIC EQUIP     | 5      | 7      | 72             | 0                       | 2,176               |
| UNDERWATER LOG EQUIP   | 0      | 5      | 207            | 6,169                   | 5,716               |
| VALVES                 | 2,070  | 2,814  | 59,254         | 180                     | 4,118,580           |
| MISC PARTS             | 175    | 117    | 2,398          | 1,010                   | 31,842              |
| LAUNDRY EQUIP          | 104    | 95     | 561            | 5,507                   | 10,346              |
| TANKS                  | 9      | 27     | 764            | 37,532                  | 10,353              |
| PIPE, HOSE, & FITTINGS | 3      | 5      | 139            | 5,878                   | 3,302               |
| ASW EQUIP              | 14     | 3      | 70             | 10,735                  | 598                 |
| YELLOW GEAR            | 364    | 1,390  | 1,787          | 0                       | 42,385              |
| PERISCOPES             | 0      | 1      | 361            | 7,762                   | 5,750               |
| MISC EQUIP             | 99     | 39     | 1,706          | 248                     | 768,456             |
| GRAND TOTALS           | 10,546 | 12,595 | 188,731        |                         | 11,499,934          |

### A.3 APL Statistical Summary

| Nomenclature       | 10 Yr<br>Ave | 5 Yr<br>Ave | Constant<br>Coeff | Total<br>Coeff | Deliveries<br>Coeff | Constant<br>T-Ratio | Total Ships<br>T-Ratio | Deliveries<br>T-Ratio |
|--------------------|--------------|-------------|-------------------|----------------|---------------------|---------------------|------------------------|-----------------------|
| PUMPS              | 364          | 479         |                   |                |                     |                     |                        |                       |
| BOILERS            | 8            | 9           |                   |                |                     |                     |                        |                       |
| HEAT EXCHANGERS    | 57           | 72          |                   |                |                     |                     |                        |                       |
| CONDENSERS         | 11           | 11          |                   |                |                     |                     |                        |                       |
| TURBINES           | 19           | 23          |                   |                |                     |                     |                        |                       |
| COMPRESSORS        | 47           | 59          |                   |                |                     |                     |                        |                       |
| HEATERS            | 172          | 182         |                   |                |                     |                     |                        |                       |
| DISTILLING PLANTS  | 10           | 11          |                   |                |                     |                     |                        |                       |
| BATTERY CHARGERS   | 25           | 35          |                   |                |                     |                     |                        |                       |
| METERS             | 21           | 29          |                   |                |                     |                     |                        |                       |
| CONVERTERS         | 32           | 40          |                   |                |                     |                     |                        |                       |
| TRANSFORMERS       | 9            | 6           |                   |                |                     |                     |                        |                       |
| CIRCUIT BREAKERS   | 150          | 164         |                   |                |                     |                     |                        |                       |
| CONTROLLERS        | 459          | 624         | (2,877.000)       | 6.60620        |                     | (7.62)              | 8.95                   |                       |
| GENERATORS         | 46           | 58          | (285.370)         | 0.558300       | 3.249000            | (4.13)              | 4.05                   | 3.19                  |
| MOTORS             | 740          | 981         |                   |                |                     |                     |                        |                       |
| MOTOR GENERATORS   | 8            | 9           |                   |                |                     |                     |                        |                       |
| RELAYS             | 58           | 51          |                   |                |                     |                     |                        |                       |
| RHEOSTATS          | 5            | 8           |                   |                |                     |                     |                        |                       |
| SWITCHES           | 258          | 336         | (1,295.500)       | 3.07690        |                     | (4.97)              | 5.97                   |                       |
| SWITCHBOARDS       | 73           | 94          |                   |                |                     |                     |                        |                       |
| VISUAL ALARMS      | 18           | 28          |                   |                |                     |                     |                        |                       |
| LIGHTING FIXTURES  | 24           | 38          |                   |                |                     |                     |                        |                       |
| GYRO COMPASSES     | 20           | 26          |                   |                |                     |                     |                        |                       |
| PROJECTION EQUIP   | 1            | 2           |                   |                |                     |                     |                        |                       |
| I/C EQUIP          | 46           | 53          |                   |                |                     |                     |                        |                       |
| NAVIGATIONAL EQUIP | 15           | 24          | (169.330)         | 0.36410        |                     | (4.61)              | 5.01                   |                       |
| INJECTORS          | 3            | 5           |                   |                |                     |                     |                        |                       |
| BURNERS            | 5            | 6           |                   |                |                     |                     |                        |                       |
| MARINE HARDWARE    | 40           | 50          |                   |                |                     |                     |                        |                       |
| REFRIG EQUIP       | 255          | 346         | (1,131.000)       | 2.86400        |                     | (4.06)              | 4.93                   |                       |
| AIR CONDITIONING   | 26           | 26          |                   |                |                     |                     |                        |                       |
| STARTERS           | 14           | 20          |                   |                |                     |                     |                        |                       |
| WIPERS             | 5            | 7           |                   |                |                     |                     |                        |                       |
| AUDIBLE ALARMS     | 5            | 10          |                   |                |                     |                     |                        |                       |
| BEARINGS           | 10           | 14          |                   |                |                     |                     |                        |                       |
| INDICATORS         | 127          | 161         |                   |                |                     |                     |                        |                       |
| CLUTCHES           | 5            | 8           |                   |                |                     |                     |                        |                       |
| FANS               | 22           | 106         |                   |                |                     |                     |                        |                       |
| SHOP EQUIP         | 165          | 207         | (475.500)         | 1.053000       | 7.143000            | (2.90)              | 3.11                   | 2.36                  |
| REGULATORS         | 19           | 23          |                   |                |                     |                     |                        |                       |
| GALLEY EQUIP       | 146          | 203         |                   |                |                     |                     |                        |                       |
| DEHYDRATORS        | 11           | 13          |                   |                |                     |                     |                        |                       |
| GAGES              | 108          | 130         |                   |                |                     |                     |                        |                       |
| TESTING EQUIP      | 68           | 67          |                   |                |                     |                     |                        |                       |
| FILTERS            | 164          | 199         |                   |                |                     |                     |                        |                       |
| PANELS             | 224          | 250         |                   |                |                     |                     |                        |                       |

# A.3 APL Statistical Summary

| Nomenclature           | 10 Yr<br>Ave | 5 Yr<br>Ave | Constant<br>Coeff | Total<br>Coeff | Deliveries<br>Coeff | Constant<br>T-Ratio | Total Ships<br>T-Ratio | Deliveries<br>T-Ratio |
|------------------------|--------------|-------------|-------------------|----------------|---------------------|---------------------|------------------------|-----------------------|
| ISOLATORS              | 0            | 0           |                   |                |                     |                     |                        |                       |
| HYDRALIC EQUIP         | 74           | 118         | (893.900)         | 1.91740        |                     | (4.63)              | 5.02                   |                       |
| CAPSTANS               | 4            | 5           | (16.310)          | 0.035178       | 0.161110            | (3.52)              | 3.80                   | 2.36                  |
| REELS                  | 17           | 24          | (106.780)         | 0.24437        |                     | (3.93)              | 4.54                   |                       |
| DAVITS                 | 4            | 6           |                   |                |                     |                     |                        |                       |
| CRANES                 | 11           | 8           |                   |                |                     |                     |                        |                       |
| HOISTS                 | 35           | 40          |                   |                |                     |                     |                        |                       |
| ELEVATORS              | 12           | 10          |                   |                |                     |                     |                        |                       |
| STEERING EQUIP         | 3            | 5           |                   |                |                     |                     |                        |                       |
| CONTROL EQUIP          | 339          | 389         |                   |                |                     |                     |                        |                       |
| WINCHES                | 26           | 40          | (225.600)         | 0.49850        |                     | (4.18)              | 4.67                   |                       |
| WINDLASSES             | 4            | 4           |                   |                |                     |                     |                        |                       |
| FIREFIGHTING EQUIP     | 45           | 60          |                   |                |                     |                     |                        |                       |
| LUBRICATORS            | 12           | 14          |                   |                |                     |                     |                        |                       |
| ENGINES                | 42           | 54          |                   |                |                     |                     |                        |                       |
| PLUMBING EQUIP         | 10           | 12          |                   |                |                     |                     |                        |                       |
| GEARS AND REDUCERS     | 50           | 63          |                   |                |                     |                     |                        |                       |
| GOVERNORS              | 22           | 35          | (217.260)         | 0.47387        |                     | (5.44)              | 6.00                   |                       |
| IGNITION EQUIP         | 0            | 0           |                   |                |                     |                     |                        |                       |
| EJECTORS               | 4            | 5           |                   |                |                     |                     |                        |                       |
| EDUCTORS               | 2            | 3           | (32.105)          | 0.06695        |                     | (9.50)              | 10.02                  |                       |
| STRAINERS              | 107          | 106         |                   |                |                     |                     |                        |                       |
| PURIFIERS              | 19           | 26          |                   |                |                     |                     |                        |                       |
| TRAPS-STEAM            | 13           | 14          |                   |                |                     |                     |                        |                       |
| COUPLINGS              | 36           | 53          | (299.710)         | 0.66392        |                     | (6.51)              | 7.30                   |                       |
| SILENCING EQUIP        | 4            | 7           |                   |                |                     |                     |                        |                       |
| BRAKES                 | 33           | 41          |                   |                |                     |                     |                        |                       |
| BLOWERS                | 9            | 5           |                   |                |                     |                     |                        |                       |
| WELDING SYSTEMS        | 27           | 38          |                   |                |                     |                     |                        |                       |
| BOAT PROPULSION        | 26           | 33          |                   |                |                     |                     |                        |                       |
| DECK MACHINERY         | 48           | 42          |                   |                |                     |                     |                        |                       |
| PHOTOGRAPHIC EQUIP     | 3            | 3           |                   |                |                     |                     |                        |                       |
| UNDERWATER LOG EQUIP   | 2            | 1           |                   |                |                     |                     |                        |                       |
| VALVES                 | 1,968        | 1961        |                   |                |                     |                     |                        |                       |
| MISC PARTS             | 227          | 287         |                   |                |                     |                     |                        |                       |
| LAUNDRY EQUIP          | 58           | 87          | (1,096.800)       | 2.35490        |                     | (4.14)              | 4.50                   |                       |
| TANKS                  | 19           | 23          |                   |                |                     |                     |                        |                       |
| PIPE, HOSE, & FITTINGS | 4            | 4           |                   |                |                     |                     |                        |                       |
| ASW EQUIP              | 6            | 10          |                   |                |                     |                     |                        |                       |
| YELLOW GEAR            | 1,207        | 1165        |                   |                |                     |                     |                        |                       |
| PERISCOPES             | 6            | 3           |                   |                |                     |                     |                        |                       |
| MISC EQUIP             | 53           | 67          |                   |                |                     |                     |                        |                       |
| GRAND TOTALS           | 8,778        | 10,183      |                   |                |                     |                     |                        |                       |

# A.3 APL Statistical Summary

| Nomenclature       | R-Squared |
|--------------------|-----------|
| PUMPS              |           |
| BOILERS            |           |
| HEAT EXCHANGERS    |           |
| CONDENSERS         |           |
| TURBINES           |           |
| COMPRESSORS        |           |
| HEATERS            |           |
| DISTILLING PLANTS  |           |
| BATTERY CHARGERS   |           |
| METERS             |           |
| CONVERTERS         |           |
| TRANSFORMERS       |           |
| CIRCUIT BREAKERS   |           |
| CONTROLLERS        | 90.70%    |
| GENERATORS         | 91.60%    |
| MOTORS             |           |
| MOTOR GENERATORS   |           |
| RELAYS             |           |
| RHEOSTATS          |           |
| SWITCHES           | 81.70%    |
| SWITCHBOARDS       |           |
| VISUAL ALARMS      |           |
| LIGHTING FIXTURES  |           |
| GYRO COMPASSES     |           |
| PROJECTION EQUIP   |           |
| I/C EQUIP          |           |
| NAVIGATIONAL EQUIP | 75.90%    |
| INJECTORS          |           |
| BURNERS            |           |
| MARINE HARDWARE    |           |
| REFRIG EQUIP       | 75.30%    |
| AIR CONDITIONING   |           |
| STARTERS           |           |
| WIPERS             |           |
| AUDIBLE ALARMS     |           |
| BEARINGS           |           |
| INDICATORS         |           |
| CLUTCHES           |           |
| FANS               |           |
| SHOP EQUIP         | 74.30%    |
| REGULATORS         |           |
| GALLEY EQUIP       |           |
| DEHYDRATORS        |           |
| GAGES              |           |
| TESTING EQUIP      |           |
| FILTERS            |           |
| PANELS             |           |

# A.3 APL Statistical Summary

| Nomenclature           | R-Squared |
|------------------------|-----------|
| ISOLATORS              |           |
| HYDRALIC EQUIP         | 75.90%    |
| CAPSTANS               | 76.80%    |
| REELS                  | 72.10%    |
| DAVITS                 |           |
| CRANES                 |           |
| HOISTS                 |           |
| ELEVATORS              |           |
| STEERING EQUIP         |           |
| CONTROL EQUIP          |           |
| WINCHES                | 73.10%    |
| WINDLASSES             |           |
| FIREFIGHTING EQUIP     |           |
| LUBRICATORS            |           |
| ENGINES                |           |
| PLUMBING EQUIP         |           |
| GEARS AND REDUCERS     |           |
| GOVERNORS              | 81.80%    |
| IGNITION EQUIP         |           |
| EJECTORS               |           |
| EDUCTORS               | 92.60%    |
| STRAINERS              |           |
| PURIFIERS              |           |
| TRAPS-STEAM            |           |
| COUPLINGS              | 86.90%    |
| SILENCING EQUIP        |           |
| BRAKES                 |           |
| BLOWERS                |           |
| WELDING SYSTEMS        |           |
| BOAT PROPULSION        |           |
| DECK MACHINERY         |           |
| PHOTOGRAPHIC EQUIP     |           |
| UNDERWATER LOG EQUIP   |           |
| VALVES                 |           |
| MISC PARTS             |           |
| LAUNDRY EQUIP          | 71.70%    |
| TANKS                  |           |
| PIPE, HOSE, & FITTINGS |           |
| ASW EQUIP              |           |
| YELLOW GEAR            |           |
| PERISCOPES             |           |
| MISC EQUIP             |           |

GRAND TOTALS

#### A.4 APL and Part Growth Results

| Nomenclature       | 1987 Projected<br>APL Growth | 1988 Projected<br>APL Growth | 1989 Projected<br>APL Growth | 1987 Add<br>New Parts | 1988 Add<br>New Parts | 1989 Add<br>New Parts |
|--------------------|------------------------------|------------------------------|------------------------------|-----------------------|-----------------------|-----------------------|
| PUMPS              | 479                          | 479                          | 479                          | 2,036                 | 2,036                 | 2,036                 |
| BOILERS            | 8                            | 8                            | 8                            | 188                   | 188                   | 188                   |
| HEAT EXCHANGERS    | 57                           | 57                           | 57                           | 114                   | 114                   | 114                   |
| CONDENSERS         | 11                           | 11                           | 11                           | 25                    | 25                    | 25                    |
| TURBINES           | 19                           | 19                           | 19                           | 537                   | 537                   | 537                   |
| COMPRESSORS        | 59                           | 59                           | 59                           | 1,136                 | 1,136                 | 1,136                 |
| HEATERS            | 172                          | 172                          | 172                          | 215                   | 215                   | 215                   |
| DISTILLING PLANTS  | 11                           | 11                           | 11                           | 44                    | 44                    | 44                    |
| BATTERY CHANGERS   | 25                           | 25                           | 25                           | 94                    | 94                    | 94                    |
| METERS             | 21                           | 21                           | 21                           | 16                    | 16                    | 16                    |
| CONVERTERS         | 40                           | 40                           | 40                           | 230                   | 230                   | 230                   |
| TRANSFORMERS       | 9                            | 9                            | 9                            | 2                     | 2                     | 2                     |
| CIRCUIT BREAKERS   | 150                          | 150                          | 150                          | 375                   | 375                   | 375                   |
| CONTROLLERS        | 982                          | 968                          | 1,120                        | 3,528                 | 3,871                 | 4,479                 |
| GENERATORS         | 75                           | 66                           | 114                          | 317                   | 279                   | 485                   |
| MOTORS             | 981                          | 981                          | 981                          | 1,226                 | 1,226                 | 1,226                 |
| MOTOR GENERATORS   | 9                            | 9                            | 9                            | 27                    | 27                    | 27                    |
| RELAYS             | 58                           | 58                           | 58                           | 73                    | 73                    | 73                    |
| RHEOSTATS          | 6                            | 6                            | 6                            | 8                     | 8                     | 8                     |
| SWITCHES           | 455                          | 495                          | 566                          | 455                   | 495                   | 566                   |
| SWITCHBOARDS       | 73                           | 73                           | 73                           | 274                   | 274                   | 274                   |
| VISUAL ALARMS      | 18                           | 18                           | 18                           | 27                    | 27                    | 27                    |
| LIGHTING FIXTURES  | 38                           | 38                           | 38                           | 48                    | 48                    | 48                    |
| GYRO COMPASSES     | 20                           | 20                           | 20                           | 190                   | 190                   | 190                   |
| PROJECTION EQUIP   | 2                            | 2                            | 2                            | 39                    | 39                    | 39                    |
| I/C EQUIP          | 46                           | 46                           | 46                           | 184                   | 184                   | 184                   |
| NAVIGATIONAL EQUIP | 38                           | 43                           | 51                           | 426                   | 479                   | 573                   |
| INJECTORS          | 3                            | 3                            | 3                            | 20                    | 20                    | 20                    |
| BURNERS            | 5                            | 5                            | 5                            | 45                    | 45                    | 45                    |
| MARINE HARDWARE    | 40                           | 40                           | 40                           | 80                    | 80                    | 80                    |
| REFRIG EQUIP       | 439                          | 476                          | 542                          | 1,097                 | 1,190                 | 1,354                 |
| AIR CONDITIONING   | 26                           | 26                           | 26                           | 95                    | 95                    | 95                    |
| STARTERS           | 14                           | 14                           | 14                           | 105                   | 105                   | 105                   |
| WIPERS             | 6                            | 6                            | 6                            | 21                    | 21                    | 21                    |
| AUDIBLE ALARMS     | 10                           | 10                           | 10                           | 25                    | 25                    | 25                    |
| BEARINGS           | 14                           | 14                           | 14                           | 18                    | 18                    | 18                    |
| INDICATORS         | 161                          | 161                          | 161                          | 403                   | 403                   | 403                   |
| CLUTCHES           | 8                            | 8                            | 8                            | 38                    | 38                    | 38                    |
| FANS               | 32                           | 32                           | 32                           | 46                    | 46                    | 46                    |
| SHOP EQUIP         | 216                          | 194                          | 297                          | 433                   | 389                   | 594                   |
| REGULATORS         | 23                           | 23                           | 23                           | 104                   | 104                   | 104                   |
| GALLEY EQUIP       | 203                          | 203                          | 203                          | 660                   | 660                   | 660                   |
| DEHYDRATORS        | 13                           | 13                           | 13                           | 72                    | 72                    | 72                    |
| GAGES              | 130                          | 130                          | 130                          | 163                   | 163                   | 163                   |
| TESTING EQUIP      | 68                           | 68                           | 68                           | 272                   | 272                   | 272                   |
| FILTERS            | 198                          | 198                          | 198                          | 495                   | 495                   | 495                   |
| PANELS             | 224                          | 224                          | 224                          | 672                   | 672                   | 672                   |



#### A.4 APL and Part Growth Results

| Nomenclature           | 1987 Projected<br>APL Growth | 1988 Projected<br>APL Growth | 1989 Projected<br>APL Growth | 1987 Add<br>New Parts | 1988 Add<br>New Parts | 1989 Add<br>New Parts |
|------------------------|------------------------------|------------------------------|------------------------------|-----------------------|-----------------------|-----------------------|
| ISOLATORS              | 0                            | 0                            | 0                            | 0                     | 0                     | 0                     |
| HYDRALIC EQUIP         | 197                          | 222                          | 266                          | 1,133                 | 1,277                 | 1,530                 |
| CAPSTANS               | 6                            | 5                            | 8                            | 22                    | 20                    | 30                    |
| REELS                  | 32                           | 35                           | 41                           | 105                   | 115                   | 133                   |
| DAVITS                 | 4                            | 4                            | 4                            | 7                     | 7                     | 7                     |
| CRANES                 | 11                           | 11                           | 11                           | 99                    | 99                    | 99                    |
| HOISTS                 | 35                           | 35                           | 35                           | 166                   | 166                   | 166                   |
| ELEVATORS              | 12                           | 12                           | 12                           | 78                    | 78                    | 78                    |
| STEERING EQUIP         | 5                            | 5                            | 5                            | 71                    | 71                    | 71                    |
| CONTROL EQUIP          | 339                          | 339                          | 339                          | 1,102                 | 1,102                 | 1,102                 |
| WINCHES                | 58                           | 65                           | 76                           | 377                   | 419                   | 494                   |
| WINDLASSES             | 4                            | 4                            | 4                            | 35                    | 35                    | 35                    |
| FIREFIGHTING EQUIP     | 60                           | 60                           | 60                           | 285                   | 285                   | 285                   |
| LUBRICATORS            | 14                           | 14                           | 14                           | 35                    | 35                    | 35                    |
| ENGINES                | 42                           | 42                           | 42                           | 4,578                 | 4,578                 | 4,578                 |
| PLUMBING EQUIP         | 10                           | 10                           | 10                           | 23                    | 23                    | 23                    |
| GEARS AND REDUCERS     | 50                           | 50                           | 50                           | 363                   | 363                   | 363                   |
| GOVERNORS              | 52                           | 59                           | 69                           | 903                   | 1,010                 | 1,198                 |
| IGNITION EQUIP         | 0                            | 0                            | 0                            | 0                     | 0                     | 0                     |
| EJECTORS               | 5                            | 5                            | 5                            | 19                    | 19                    | 19                    |
| EDUCTORS               | 6                            | 7                            | 8                            | 3                     | 3                     | 4                     |
| STRAINERS              | 107                          | 107                          | 107                          | 80                    | 80                    | 80                    |
| PURIFIERS              | 26                           | 26                           | 26                           | 611                   | 611                   | 611                   |
| TRAPS-STEAM            | 14                           | 14                           | 14                           | 14                    | 14                    | 14                    |
| COUPLINGS              | 78                           | 87                           | 102                          | 78                    | 87                    | 102                   |
| SILENCING EQUIP        | 7                            | 7                            | 7                            | 5                     | 5                     | 5                     |
| BRAKES                 | 41                           | 41                           | 41                           | 62                    | 62                    | 62                    |
| BLOWERS                | 9                            | 9                            | 9                            | 110                   | 110                   | 110                   |
| WELDING SYSTEMS        | 38                           | 38                           | 38                           | 181                   | 181                   | 181                   |
| BOAT PROPULSION        | 26                           | 26                           | 26                           | 46                    | 46                    | 46                    |
| DECK MACHINERY         | 48                           | 48                           | 48                           | 132                   | 132                   | 132                   |
| PHOTOGRAPHIC EQUIP     | 3                            | 3                            | 3                            | 9                     | 9                     | 9                     |
| UNDERWATER LOG EQUIP   | 2                            | 2                            | 2                            | 15                    | 15                    | 15                    |
| VALVES                 | 1,968                        | 1,968                        | 1,968                        | 2,952                 | 2,952                 | 2,952                 |
| MISC PARTS             | 227                          | 227                          | 227                          | 3,632                 | 3,632                 | 3,632                 |
| LAUNDRY EQUIP          | 243                          | 274                          | 328                          | 1,702                 | 1,916                 | 2,295                 |
| TANKS                  | 23                           | 23                           | 23                           | 29                    | 29                    | 29                    |
| PIPE, HOSE, & FITTINGS | 4                            | 4                            | 4                            | 4                     | 4                     | 4                     |
| ASW EQUIP              | 10                           | 10                           | 10                           | 30                    | 30                    | 30                    |
| YELLOW GEAR            | 1,207                        | 1,207                        | 1,207                        | 3,018                 | 3,018                 | 3,018                 |
| PERISCOPES             | 6                            | 6                            | 6                            | 50                    | 50                    | 50                    |
| MISC EQUIP             | 53                           | 53                           | 53                           | 93                    | 93                    | 93                    |
| GRAND TOTALS           | 10,737                       | 10,955                       | 11,549                       | 39,034                | 40,006                | 42,295                |

## **APPENDIX B : DUPLICATE PART DATA**

Appendix B provides the data used to estimate the potential number of duplicate H,M&E parts and equipment. NSLC provided the data used for the Potential Duplicate Pump Data table from the Commodity Configuration File. The method used to develop the data in the Duplicate Percentages table was described in Chapter III.

# B.1 Potential Duplicate Pump Data

| LAPL   | Capacity<br>(GPM) | Capacity<br>(CFM/CIM) | Pressure<br>(PSI) | APL's | Ship<br>Pop | Fleet<br>Pop |
|--------|-------------------|-----------------------|-------------------|-------|-------------|--------------|
| 01-001 | 300.000           |                       | 456.000           | 2     | 10          | 43           |
| 01-001 | 300.000           |                       | 467.000           | 2     | 6           | 24           |
| 01-001 | 460.000           |                       | 1,460.000         | 2     | 20          | 124          |
| 01-001 | 650.000           |                       | 775.000           | 2     | 3           | 12           |
| 01-002 | 200.000           |                       | 775.000           | 2     | 4           | 7            |
| 01-002 | 500.000           |                       | 125.000           | 2     | 4           | 12           |
| 01-002 | 75.000            |                       | 50.000            | 2     | 6           | 6            |
| 01-002 | 0.025             |                       | 100.000           | 2     | 16          | 36           |
| 01-002 | 400.000           |                       | 125.000           | 2     | 8           | 33           |
| 01-002 | 0.040             |                       | 400.000           | 2     | 67          | 138          |
| 01-002 | 95.000            |                       | 765.000           | 2     | 15          | 28           |
| 01-002 | 200.000           |                       | 100.000           | 2     | 4           | 6            |
| 01-002 | 1.700             |                       | 1,600.000         | 2     | 23          | 50           |
| 01-002 | 5.000             |                       | 3,000.000         | 2     | 18          | 56           |
| 01-002 | 90.000            |                       | 62.500            | 2     | 7           | 28           |
| 01-002 | 0.043             |                       | 1,100.000         | 2     | 30          | 56           |
| 01-002 | 225.000           |                       | 50.000            | 2     | 4           | 24           |
| 01-002 | 200.000           |                       | 50.000            | 2     | 5           | 9            |
| 01-002 | 10.000            |                       | 60.000            | 2     | 1           | 5            |
| 01-003 | 25,000.000        |                       | 20.000            | 2     | 4           | 16           |
| 01-003 | 3,450.000         |                       | 25.000            | 2     | 1           | 2            |
| 01-003 | 10,500.000        |                       | 11.690            | 2     | 3           | 8            |
| 01-003 | 16,000.000        |                       | 13.000            | 2     | 12          | 24           |
| 01-003 | 4,900.000         |                       | 24.500            | 2     | 3           | 6            |
| 01-003 | 25,000.000        |                       | 13.000            | 2     | 5           | 13           |
| 01-003 | 25,000.000        |                       | 13.500            | 2     | 5           | 15           |
| 01-003 | 18,000.000        |                       | 7.500             | 2     | 20          | 20           |
| 01-003 | 22,000.000        |                       | 7.500             | 2     | 3           | 3            |
| 01-004 | 25.000            |                       | 50.000            | 2     | 6           | 8            |
| 01-005 | 10.000            |                       | 35.000            | 2     | 6           | 12           |
| 01-005 | 27.000            |                       | 350.000           | 2     | 11          | 53           |
| 01-005 | 500.000           |                       | 60.000            | 2     | 1           | 5            |
| 01-005 | 35.000            |                       | 3,000.000         | 2     | 12          | 24           |
| 01-005 | 70.000            |                       | 1,145.000         | 2     | 31          | 167          |
| 01-005 | 35.000            |                       | 350.000           | 2     | 3           | 5            |
| 01-005 | 500.000           |                       | 55.000            | 2     | 41          | 84           |
| 01-005 | 150.000           |                       | 100.000           | 2     | 2           | 5            |
| 01-005 | 297.000           |                       | 65.000            | 2     | 15          | 30           |
| 01-005 | 150.000           |                       | 800.000           | 2     | 55          | 132          |
| 01-005 | 15.000            |                       | 400.000           | 2     | 2           | 8            |
| 01-005 | 35.000            |                       | 40.000            | 2     | 5           | 14           |
| 01-005 | 15.000            |                       | 1,050.000         | 2     | 3           | 6            |
| 01-005 | 39.000            |                       | 50.000            | 2     | 5           | 52           |
| 01-005 | 15.000            |                       | 45.000            | 2     | 5           | 18           |
| 01-005 | 30.000            |                       | 65.000            | 2     | 3           | 5            |
| 01-005 | 26.000            |                       | 3,000.000         | 2     | 4           | 12           |
| 01-005 | 1.500             |                       | 5.000             | 2     | 11          | 39           |

# B.1 Potential Duplicate Pump Data

| LAPL   | Capacity<br>(GPM) | Capacity<br>(CFM/CIM) | Pressure<br>(PSI) | APL's | Ship<br>Pop | Fleet<br>Pop |
|--------|-------------------|-----------------------|-------------------|-------|-------------|--------------|
| 01-005 | 5.000             |                       | 50.000            | 2     | 2           | 3            |
| 01-005 | 85.000            |                       | 120.000           | 2     | 91          | 332          |
| 01-005 | 60.000            |                       | 40.000            | 2     | 2           | 6            |
| 01-005 | 10.000            |                       | 2,500.000         | 2     | 11          | 19           |
| 01-005 | 53.000            |                       | 40.000            | 2     | 13          | 26           |
| 01-005 | 360.000           |                       | 75.000            | 2     | 12          | 24           |
| 01-005 | 50.000            |                       | 100.000           | 2     | 12          | 12           |
| 01-005 | 500.000           |                       | 50.000            | 2     | 12          | 53           |
| 01-005 | 550.000           |                       | 50.000            | 2     | 3           | 5            |
| 01-005 | 275.000           |                       | 50.000            | 2     | 11          | 40           |
| 01-005 | 16.000            |                       | 350.000           | 2     | 2           | 2            |
| 01-005 | 5.000             |                       | 300.000           | 2     | 5           | 46           |
| 01-005 | 300.000           |                       | 45.000            | 2     | 8           | 15           |
| 01-005 | 440.000           |                       | 60.000            | 2     | 11          | 26           |
| 01-005 | 50.000            |                       | 30.000            | 2     | 4           | 10           |
| 01-005 | 18.000            |                       | 85.000            | 2     | 99          | 383          |
| 01-005 | 30.000            |                       | 30.000            | 2     | 19          | 38           |
| 01-005 | 50.000            |                       | 25.000            | 2     | 3           | 16           |
| 01-005 | 90.000            |                       | 25.000            | 2     | 20          | 40           |
| 01-005 | 750.000           |                       | 50.000            | 2     | 4           | 18           |
| 01-005 | 600.000           |                       | 55.000            | 2     | 23          | 46           |
| 01-005 | 720.000           |                       | 50.000            | 2     | 5           | 10           |
| 01-005 | 11.000            |                       | 30.000            | 2     | 3           | 14           |
| 01-005 | 20.000            |                       | 70.000            | 2     | 2           | 2            |
| 01-005 | 240.000           |                       | 60.000            | 2     | 32          | 37           |
| 01-005 | 24.600            |                       | 85.000            | 2     | 3           | 12           |
| 01-005 | 475.000           |                       | 50.000            | 2     | 27          | 55           |
| 01-005 | 20.000            |                       | 50.000            | 2     | 12          | 27           |
| 01-005 | 250.000           |                       | 100.000           | 2     | 3           | 8            |
| 01-005 | 710.000           |                       | 60.000            | 2     | 4           | 8            |
| 01-005 | 100.000           |                       | 25.000            | 2     | 4           | 5            |
| 01-005 | 47.000            |                       | 18.000            | 2     | 4           | 17           |
| 01-005 | 30.000            |                       | 400.000           | 2     | 11          | 29           |
| 01-005 | 50.000            |                       | 720.000           | 2     | 2           | 8            |
| 01-006 | 6.500             |                       | 2.200             | 2     | 1           | 3            |
| 01-007 | 15.000            |                       | 50.000            | 2     | 57          | 120          |
| 01-007 | 4.300             |                       | 150.000           | 2     | 2           | 8            |
| 01-007 | 20.000            |                       | 100.000           | 2     | 14          | 20           |
| 01-007 | 4.500             |                       | 100.000           | 2     | 1           | 3            |
| 01-007 | 17.000            |                       | 50.000            | 2     | 8           | 27           |
| 01-007 | 30.700            |                       | 600.000           | 2     | 1           | 4            |
| 01-007 | 15.000            |                       | 25.000            | 2     | 9           | 10           |
| 01-007 | 100.000           |                       | 50.000            | 2     | 7           | 11           |
| 01-007 | 40.000            |                       | 25.000            | 2     | 3           | 5            |
| 01-007 | 100.000           |                       | 25.000            | 2     | 4           | 5            |
| 01-007 | 4.000             |                       | 25.000            | 2     | 43          | 99           |
| 01-007 | 6.000             |                       | 50.000            | 2     | 9           | 32           |

# B.1 Potential Duplicate Pump Data

| LAPL   | Capacity<br>(GPM) | Capacity<br>(CFM/CIM) | Pressure<br>(PSI) | APL's | Ship<br>Pop | Fleet<br>Pop |
|--------|-------------------|-----------------------|-------------------|-------|-------------|--------------|
| 01-007 | 42.000            |                       | 85.000            | 2     | 9           | 49           |
| 01-007 | 5.000             |                       | 50.000            | 2     | 2           | 3            |
| 01-007 | 10.000            |                       | 42.000            | 2     | 8           | 18           |
| 01-007 | 75.000            |                       | 60.000            | 2     | 6           | 27           |
| 01-007 | 1.500             |                       | 75.000            | 2     | 210         | 572          |
| 01-007 | 35.000            |                       | 400.000           | 2     | 8           | 16           |
| 01-008 | 25.000            |                       | 25.000            | 2     | 8           | 19           |
| 01-008 | 5.800             |                       | 100.000           | 2     | 21          | 35           |
| 01-008 | 6.500             |                       | 100.000           | 2     | 187         | 327          |
| 01-008 | 1.410             |                       | 100.000           | 2     | 3           | 4            |
| 01-008 | 8.000             |                       | 60.000            | 2     | 9           | 54           |
| 01-008 | 3.000             |                       | 30.000            | 2     | 10          | 46           |
| 01-008 | 22.000            |                       | 100.000           | 2     | 22          | 177          |
| 01-008 | 15.000            |                       | 50.000            | 2     | 13          | 24           |
| 01-008 | 3.500             |                       | 55.000            | 2     | 1           | 8            |
| 01-008 | 2.300             |                       | 200.000           | 2     | 49          | 61           |
| 01-008 | 12.000            |                       | 40.000            | 2     | 2           | 8            |
| 01-009 | 8.000             |                       | 100.000           | 2     | 15          | 35           |
| 01-009 | 6.000             |                       | 30.000            | 2     | 1           | 8            |
| 01-009 | 11.000            |                       | 2,000.000         | 2     | 13          | 75           |
| 01-009 | 35.000            |                       | 100.000           | 2     | 3           | 5            |
| 01-009 | 11.000            |                       | 100.000           | 2     | 2           | 3            |
| 01-009 | 15.300            |                       | 2,000.000         | 2     | 2           | 8            |
| 01-009 | 11.000            |                       | 2,500.000         | 2     | 30          | 49           |
| 01-009 | 2.500             |                       | 1,500.000         | 2     | 7           | 30           |
| 01-009 | 10.000            |                       | 50.000            | 2     | 6           | 6            |
| 01-009 | 4.700             |                       | 1,000.000         | 2     | 13          | 39           |
| 01-009 | 10.000            |                       | 3,000.000         | 2     | 11          | 13           |
| 01-009 | 15.000            |                       | 2,000.000         | 2     | 8           | 48           |
| 01-009 | 25.000            |                       | 20.000            | 2     | 3           | 12           |
| 01-009 | 20.000            |                       | 50.000            | 2     | 2           | 3            |
| 01-009 | 125.000           |                       | 100.000           | 2     | 2           | 2            |
| 01-009 | 12.000            |                       | 100.000           | 2     | 86          | 153          |
| 01-009 | 100.000           |                       | 80.000            | 2     | 39          | 75           |
| 01-009 | 1.500             |                       | 1,500.000         | 2     | 13          | 129          |
| 01-009 | 100.000           |                       | 60.000            | 2     | 38          | 44           |
| 01-009 | 38.000            |                       | 100.000           | 2     | 29          | 56           |
| 01-009 | 35.000            |                       | 775.000           | 2     | 3           | 10           |
| 01-009 | 5.000             |                       | 500.000           | 2     | 12          | 13           |
| 01-009 | 8.000             |                       | 1,500.000         | 2     | 31          | 35           |
| 01-009 | 7.400             |                       | 500.000           | 2     | 81          | 119          |
| 01-009 | 20.000            |                       | 70.000            | 2     | 7           | 8            |
| 01-009 | 200.000           |                       | 125.000           | 2     | 12          | 33           |
| 01-009 | 15.000            |                       | 1,500.000         | 2     | 1           | 3            |
| 01-009 | 6.000             |                       | 2,000.000         | 2     | 5           | 10           |
| 01-009 | 7.500             |                       | 100.000           | 2     | 4           | 4            |
| 01-010 | 7.000             |                       | 3,000.000         | 2     | 5           | 28           |

# B.1 Potential Duplicate Pump Data

| LAPL   | Capacity<br>(GPM) | Capacity<br>(CFM/CIM) | Pressure<br>(PSI) | APL's | Ship<br>Pop | Fleet<br>Pop |
|--------|-------------------|-----------------------|-------------------|-------|-------------|--------------|
| 01-010 | 181.000           |                       | 5,000.000         | 2     | 8           | 8            |
| 01-010 | 46.000            |                       | 5,000.000         | 2     | 7           | 54           |
| 01-010 | 29.000            |                       | 1,500.000         | 2     | 8           | 8            |
| 01-010 | 6.500             |                       | 2,500.000         | 2     | 11          | 11           |
| 01-010 | 61.000            |                       | 3,500.000         | 2     | 4           | 8            |
| 01-010 | 110.000           |                       | 1,900.000         | 2     | 11          | 77           |
| 01-010 | 5.000             |                       | 1,500.000         | 2     | 14          | 17           |
| 01-010 | 119.000           |                       | 5,000.000         | 2     | 5           | 7            |
| 01-010 | 59.000            |                       | 3,000.000         | 2     | 9           | 18           |
| 01-010 | 10.000            |                       | 1,100.000         | 2     | 2           | 3            |
| 01-010 | 202.290           |                       | 3,000.000         | 2     | 4           | 8            |
| 01-010 | 77.500            |                       | 2,000.000         | 2     | 4           | 13           |
| 01-010 | 5.000             |                       | 1,000.000         | 2     | 14          | 27           |
| 01-010 | 62.400            |                       | 2,400.000         | 2     | 16          | 32           |
| 01-010 | 56.300            |                       | 1,350.000         | 2     | 4           | 12           |
| 01-010 | 180.000           |                       | 4,100.000         | 2     | 3           | 6            |
| 01-010 | 34.000            |                       | 5,000.000         | 2     | 3           | 6            |
| 01-010 | 3.000             |                       | 3,000.000         | 2     | 2           | 5            |
| 01-010 | 56.200            |                       | 3,000.000         | 2     | 3           | 4            |
| 01-010 | 122.000           |                       | 950.000           | 2     | 4           | 40           |
| 01-010 | 55.000            |                       | 3,000.000         | 2     | 2           | 3            |
| 01-010 | 48.000            |                       | 3,000.000         | 2     | 7           | 29           |
| 01-010 | 37.500            |                       | 3,000.000         | 2     | 6           | 48           |
| 01-010 | 9.000             |                       | 2,000.000         | 2     | 9           | 18           |
| 01-010 | 15.700            |                       | 2,000.000         | 2     | 1           | 2            |
| 01-010 | 148.800           |                       | 3,000.000         | 2     | 2           | 4            |
| 01-010 | 116.700           |                       | 3,500.000         | 2     | 3           | 7            |
| 01-010 | 175.000           |                       | 2,000.000         | 2     | 7           | 25           |
| 01-010 | 20.000            |                       | 2,500.000         | 2     | 10          | 91           |
| 01-011 | 75.000            |                       | 60.000            | 2     | 8           | 23           |
| 01-011 | 30.000            |                       | 3.000             | 2     | 10          | 27           |
| 01-011 | 700.000           |                       | 15.000            | 2     | 6           | 21           |
| 01-011 | 40.000            |                       | 50.000            | 2     | 17          | 33           |
| 01-011 | 100.000           |                       | 15.000            | 2     | 2           | 2            |
| 01-011 | 1,620.000         |                       | 75.000            | 2     | 5           | 32           |
| 01-011 | 200.000           |                       | 30.000            | 2     | 3           | 11           |
| 01-011 | 40.000            |                       | 30.000            | 2     | 1           | 2            |
| 01-011 | 720.000           |                       | 75.000            | 2     | 13          | 45           |
| 01-011 | 340.000           |                       | 48.000            | 2     | 3           | 7            |
| 01-011 | 20.000            |                       | 40.000            | 2     | 6           | 13           |
| 01-011 | 2,575.000         |                       | 14.000            | 2     | 2           | 8            |
| 01-011 | 50.000            |                       | 25.000            | 2     | 2           | 4            |
| 01-011 | 1,200.000         |                       | 150.000           | 2     | 4           | 15           |
| 01-011 | 50.000            |                       | 80.000            | 2     | 8           | 18           |
| 01-011 | 45.000            |                       | 50.000            | 2     | 2           | 5            |
| 01-011 | 20.000            |                       | 10.000            | 2     | 2           | 2            |
| 01-011 | 900.000           |                       | 60.000            | 2     | 4           | 16           |

# B.1 Potential Duplicate Pump Data

| LAPL   | Capacity<br>(GPM) | Capacity<br>(CFM/CIM) | Pressure<br>(PSI) | APL's | Ship<br>Pop | Fleet<br>Pop |
|--------|-------------------|-----------------------|-------------------|-------|-------------|--------------|
| 01-011 | 913.000           |                       | 45.000            | 2     | 2           | 6            |
| 01-011 | 300.000           |                       | 90.000            | 2     | 6           | 12           |
| 01-011 | 1,250.000         |                       | 40.000            | 2     | 3           | 4            |
| 01-011 | 120.000           |                       | 37.300            | 2     | 1           | 2            |
| 01-011 | 300.000           |                       | 35.600            | 2     | 2           | 6            |
| 01-011 | 350.000           |                       | 22.300            | 2     | 1           | 2            |
| 01-011 | 100.000           |                       | 30.000            | 2     | 171         | 514          |
| 01-011 | 280.000           |                       | 30.000            | 2     | 1           | 3            |
| 01-011 | 2,500.000         |                       | 12.000            | 2     | 3           | 13           |
| 01-011 | 900.000           |                       | 50.000            | 2     | 1           | 8            |
| 01-011 | 25.000            |                       | 15.000            | 2     | 15          | 20           |
| 01-011 | 40.000            |                       | 43.000            | 2     | 3           | 6            |
| 01-011 | 100.000           |                       | 39.000            | 2     | 52          | 264          |
| 01-011 | 15.000            |                       | 17.500            | 2     | 4           | 4            |
| 01-011 | 5.000             |                       | 10.000            | 2     | 3           | 4            |
| 01-011 | 10.000            |                       | 22.000            | 2     | 7           | 14           |
| 01-011 | 200.000           |                       | 20.000            | 2     | 5           | 7            |
| 01-011 | 250.000           |                       | 33.000            | 2     | 2           | 9            |
| 01-011 | 10.000            |                       | 15.000            | 2     | 2           | 3            |
| 01-011 | 10.000            |                       | 35.000            | 2     | 2           | 2            |
| 01-011 | 10.000            |                       | 60.000            | 2     | 1           | 4            |
| 01-011 | 250.000           |                       | 125.000           | 2     | 5           | 5            |
| 01-011 | 3,200.000         |                       | 12.000            | 2     | 3           | 17           |
| 01-011 | 15.000            |                       | 75.000            | 2     | 1           | 4            |
| 01-011 | 400.000           |                       | 30.000            | 2     | 2           | 18           |
| 01-011 | 520.000           |                       | 60.000            | 2     | 2           | 3            |
| 01-011 | 100.000           |                       | 48.000            | 2     | 2           | 4            |
| 01-011 | 15.000            |                       | 8.000             | 2     | 32          | 42           |
| 01-011 | 180.000           |                       | 28.000            | 2     | 1           | 4            |
| 01-011 | 6.000             |                       | 15.000            | 2     | 3           | 8            |
| 01-011 | 25.000            |                       | 4.000             | 2     | 1           | 2            |
| 01-011 | 950.000           |                       | 30.000            | 2     | 2           | 5            |
| 01-011 | 450.000           |                       | 30.000            | 2     | 7           | 12           |
| 01-011 | 240.000           |                       | 65.000            | 2     | 2           | 6            |
| 01-011 | 700.000           |                       | 45.000            | 2     | 39          | 78           |
| 01-011 | 225.000           |                       | 24.000            | 2     | 8           | 13           |
| 01-011 | 675.000           |                       | 60.000            | 2     | 2           | 8            |
| 01-011 | 1,500.000         |                       | 65.000            | 2     | 5           | 20           |
| 01-011 | 650.000           |                       | 100.000           | 2     | 5           | 38           |
| 01-011 | 30.000            |                       | 50.000            | 2     | 5           | 12           |
| 01-011 | 650.000           |                       | 30.000            | 2     | 2           | 6            |
| 01-011 | 800.000           |                       | 75.000            | 2     | 2           | 6            |
| 01-011 | 175.000           |                       | 125.000           | 2     | 7           | 14           |
| 01-011 | 450.000           |                       | 100.000           | 2     | 3           | 3            |
| 01-011 | 1,000.000         |                       | 35.000            | 2     | 2           | 6            |
| 01-011 | 50.000            |                       | 34.000            | 2     | 3           | 3            |
| 01-011 | 575.000           |                       | 70.000            | 2     | 2           | 4            |

# B.1 Potential Duplicate Pump Data

| LAPL   | Capacity<br>(GPM) | Capacity<br>(CFM/CIM) | Pressure<br>(PSI) | APL's | Ship<br>Pop | Fleet<br>Pop |
|--------|-------------------|-----------------------|-------------------|-------|-------------|--------------|
| 01-011 | 50.000            |                       | 18.000            | 2     | 4           | 10           |
| 01-011 | 5.000             |                       | 15.000            | 2     | 4           | 6            |
| 01-011 | 1,150.000         |                       | 62.000            | 2     | 5           | 7            |
| 01-011 | 100.000           |                       | 69.000            | 2     | 2           | 4            |
| 01-011 | 350.000           |                       | 29.000            | 2     | 2           | 5            |
| 01-011 | 160.000           |                       | 34.000            | 2     | 1           | 3            |
| 01-011 | 102.000           |                       | 74.000            | 2     | 27          | 54           |
| 01-011 | 160.000           |                       | 35.000            | 2     | 2           | 4            |
| 01-011 | 70.000            |                       | 11.000            | 2     | 4           | 10           |
| 01-011 | 30.000            |                       | 50.000            | 2     | 4           | 7            |
| 01-011 | 70.000            |                       | 30.000            | 2     | 4           | 9            |
| 01-011 | 1,300.000         |                       | 122.000           | 2     | 5           | 12           |
| 01-011 | 70.000            |                       | 25.000            | 2     | 2           | 8            |
| 01-011 | 10.000            |                       | 30.000            | 2     | 21          | 82           |
| 01-011 | 1,750.000         |                       | 168.000           | 2     | 22          | 74           |
| 01-011 | 153.000           |                       | 100.000           | 2     | 40          | 40           |
| 01-011 | 12,500.000        |                       | 27.000            | 2     | 3           | 24           |
| 01-011 | 150.000           |                       | 15.000            | 2     | 50          | 127          |
| 01-011 | 250.000           |                       | 35.000            | 2     | 6           | 13           |
| 01-011 | 5.000             |                       | 2.000             | 2     | 46          | 139          |
| 01-011 | 850.000           |                       | 35.000            | 2     | 2           | 9            |
| 01-011 | 40.000            |                       | 15.000            | 2     | 2           | 2            |
| 01-011 | 80.000            |                       | 22.000            | 2     | 2           | 3            |
| 01-011 | 35.000            |                       | 75.000            | 2     | 9           | 12           |
| 01-011 | 1,500.000         |                       | 45.000            | 2     | 6           | 5            |
| 01-011 | 150.000           |                       | 99.000            | 2     | 1           | 2            |
| 01-011 | 850.000           |                       | 90.000            | 2     | 48          | 99           |
| 01-011 | 625.000           |                       | 25.000            | 2     | 3           | 12           |
| 01-011 | 780.000           |                       | 60.000            | 2     | 2           | 4            |
| 01-011 | 575.000           |                       | 29.000            | 2     | 2           | 6            |
| 01-011 | 575.000           |                       | 23.000            | 2     | 4           | 12           |
| 01-011 | 1,300.000         |                       | 14.000            | 2     | 1           | 2            |
| 01-011 | 300.000           |                       | 35.000            | 2     | 1           | 3            |
| 01-011 | 600.000           |                       | 45.000            | 2     | 9           | 36           |
| 01-011 | 350.000           |                       | 70.000            | 2     | 5           | 23           |
| 01-011 | 150.000           |                       | 28.000            | 2     | 84          | 187          |
| 01-011 | 280.000           |                       | 40.000            | 2     | 34          | 122          |
| 01-011 | 600.000           |                       | 25.000            | 2     | 6           | 14           |
| 01-011 | 250.000           |                       | 58.000            | 2     | 3           | 14           |
| 01-011 | 150.000           |                       | 40.000            | 2     | 9           | 30           |
| 01-011 | 850.000           |                       | 20.000            | 2     | 2           | 8            |
| 01-011 | 150.000           |                       | 58.500            | 2     | 3           | 11           |
| 01-011 | 85.000            |                       | 120.000           | 2     | 4           | 16           |
| 01-011 | 35.000            |                       | 17.000            | 2     | 6           | 6            |
| 01-011 | 10.000            |                       | 20.000            | 2     | 4           | 5            |
| 01-011 | 600.000           |                       | 33.400            | 2     | 6           | 14           |
| 01-011 | 20.000            |                       | 60.000            | 2     | 3           | 7            |



# B.1 Potential Duplicate Pump Data

| LAPL   | Capacity<br>(GPM) | Capacity<br>(CFM/CIM) | Pressure<br>(PSI) | APL's | Ship<br>Pop | Fleet<br>Pop |
|--------|-------------------|-----------------------|-------------------|-------|-------------|--------------|
| Ø1-Ø11 | 600.000           |                       | 29.800            | 2     | 50          | 97           |
| Ø1-Ø11 | 300.000           |                       | 100.000           | 2     | 3           | 5            |
| Ø1-Ø11 | 100.000           |                       | 66.000            | 2     | 3           | 4            |
| Ø1-Ø11 | 15.000            |                       | 70.000            | 2     | 7           | 7            |
| Ø1-Ø11 | 40.000            |                       | 40.000            | 2     | 3           | 5            |
| Ø1-Ø11 | 225.000           |                       | 100.000           | 2     | 13          | 26           |
| Ø1-Ø11 | 130.000           |                       | 100.000           | 2     | 44          | 88           |
| Ø1-Ø11 | 75.000            |                       | 40.000            | 2     | 1           | 5            |
| Ø1-Ø11 | 450.000           |                       | 70.000            | 2     | 25          | 118          |
| Ø1-Ø11 | 80.000            |                       | 100.000           | 2     | 44          | 89           |
| Ø1-Ø11 | 900.000           |                       | 30.000            | 2     | 3           | 11           |
| Ø1-Ø11 | 10.000            |                       | 78.000            | 2     | 14          | 54           |
| Ø1-Ø11 | 125.000           |                       | 25.000            | 2     | 1           | 4            |
| Ø1-Ø14 | 10.000            |                       | 25.000            | 2     | 1           | 3            |
| Ø1-Ø14 | 0.000             | 4.500                 | 375.000           | 2     | 9           | 122          |
| Ø1-Ø14 | 2.500             |                       | 450.000           | 2     | 71          | 87           |
| Ø1-Ø14 | 4.000             |                       | 15.000            | 2     | 6           | 6            |
| Ø1-Ø14 | 8.000             |                       | 15.000            | 2     | 3           | 12           |
| Ø1-Ø14 | 7.000             |                       | 10.000            | 2     | 9           | 15           |
| Ø1-Ø14 | 10.000            |                       | 20.000            | 2     | 6           | 12           |
| Ø1-Ø14 | 10.000            |                       | 5.000             | 2     | 10          | 23           |
| Ø1-Ø14 | 0.500             |                       | 750.000           | 2     | 7           | 16           |
| Ø1-Ø14 | 10.000            |                       | 10.000            | 2     | 5           | 12           |
| Ø1-Ø14 | 3.800             |                       | 100.000           | 2     | 3           | 5            |
| Ø1-Ø14 | 0.000             | 1.080                 | 1,500.000         | 2     | 20          | 109          |
| Ø1-Ø14 | 1.420             |                       | 900.000           | 2     | 1           | 153          |
| Ø1-Ø14 | 6.000             |                       | 22.000            | 2     | 13          | 51           |
| Ø1-Ø14 | 5.000             |                       | 10.000            | 2     | 7           | 15           |
| Ø1-Ø14 | 0.000             | 0.660                 | 3,000.000         | 2     | 11          | 111          |
| Ø1-Ø17 | 75.000            |                       | 75.000            | 2     | 6           | 48           |
| Ø1-Ø17 | 100.000           |                       | 41.000            | 2     | 23          | 48           |
| Ø1-Ø17 | 100.000           |                       | 70.000            | 2     | 2           | 12           |
| Ø1-Ø17 | 40.000            |                       | 90.000            | 2     | 7           | 23           |
| Ø1-Ø17 | 25.000            |                       | 76.000            | 2     | 4           | 5            |
| Ø1-Ø17 | 325.000           |                       | 44.000            | 2     | 12          | 48           |
| Ø1-Ø17 | 1.500             |                       | 13.500            | 2     | 39          | 39           |
| Ø1-Ø17 | 1,150.000         |                       | 24.000            | 2     | 1           | 8            |
| Ø1-Ø17 | 715.000           |                       | 45.000            | 2     | 6           | 36           |
| Ø1-Ø17 | 4.000             |                       | 35.000            | 2     | 2           | 4            |
| Ø1-Ø17 | 10.000            |                       | 40.000            | 2     | 1           | 2            |
| Ø1-Ø17 | 7.500             |                       | 22.000            | 2     | 11          | 25           |
| Ø1-Ø17 | 1.000             |                       | 25.000            | 2     | 1           | 2            |
| Ø1-Ø17 | 100.000           |                       | 55.000            | 2     | 6           | 24           |
| Ø1-Ø17 | 20.000            |                       | 30.000            | 2     | 1           | 2            |
| Ø1-Ø17 | 140.000           |                       | 20.220            | 2     | 3           | 7            |
| Ø1-Ø17 | 480.000           |                       | 65.000            | 2     | 25          | 149          |
| Ø1-Ø17 | 2.000             |                       | 33.400            | 2     | 31          | 31           |

# B.1 Potential Duplicate Pump Data

| LAPL   | Capacity<br>(GPM) | Capacity<br>(CFM/CIM) | Pressure<br>(PSI) | APL's | Ship<br>Pop | Fleet<br>Pop |
|--------|-------------------|-----------------------|-------------------|-------|-------------|--------------|
| 01-017 | 15.000            |                       | 41.000            | 2     | 15          | 33           |
| 01-017 | 30.000            |                       | 60.000            | 2     | 44          | 132          |
| 01-017 | 50.000            |                       | 35.000            | 2     | 3           | 5            |
| 01-017 | 30.000            |                       | 75.000            | 2     | 7           | 23           |
| 01-017 | 225.000           |                       | 42.500            | 2     | 14          | 56           |
| 01-017 | 30.000            |                       | 85.000            | 2     | 13          | 39           |
| 01-017 | 375.000           |                       | 70.000            | 2     | 3           | 36           |
| 01-017 | 25.000            |                       | 35.000            | 2     | 3           | 10           |
| 01-017 | 85.000            |                       | 100.000           | 2     | 2           | 2            |
| 01-017 | 25.000            |                       | 25.500            | 2     | 31          | 31           |
| 01-017 | 85.000            |                       | 75.000            | 2     | 6           | 10           |
| 01-017 | 50.000            |                       | 65.000            | 2     | 2           | 8            |
| 01-017 | 240.000           |                       | 65.000            | 2     | 6           | 16           |
| 01-017 | 25.000            |                       | 70.000            | 2     | 6           | 15           |
| 01-017 | 490.000           |                       | 65.000            | 2     | 28          | 173          |
| 01-017 | 430.000           |                       | 60.000            | 2     | 28          | 110          |
| 01-017 | 15.000            |                       | 40.000            | 2     | 2           | 3            |
| 01-017 | 430.000           |                       | 65.000            | 2     | 44          | 131          |
| 01-017 | 360.000           |                       | 35.000            | 2     | 4           | 13           |
| 01-017 | 100.000           |                       | 34.100            | 2     | 3           | 5            |
| 01-017 | 530.000           |                       | 130.000           | 2     | 6           | 24           |
| 01-017 | 148.000           |                       | 28.000            | 2     | 9           | 20           |
| 01-017 | 250.000           |                       | 30.000            | 2     | 3           | 9            |
| 01-017 | 50.000            |                       | 62.000            | 2     | 4           | 21           |
| 01-017 | 15.000            |                       | 27.000            | 2     | 43          | 43           |
| 01-017 | 30.000            |                       | 58.000            | 2     | 14          | 32           |
| 01-017 | 255.000           |                       | 34.000            | 2     | 44          | 165          |
| 01-017 | 1.500             |                       | 28.900            | 2     | 41          | 43           |
| 01-017 | 10.000            |                       | 81.000            | 2     | 5           | 10           |
| 01-017 | 40.000            |                       | 50.000            | 2     | 14          | 32           |
| 01-017 | 65.000            |                       | 75.000            | 2     | 1           | 5            |
| 01-017 | 40.000            |                       | 45.000            | 2     | 45          | 93           |
| 01-017 | 10.000            |                       | 50.000            | 2     | 59          | 119          |
| 01-017 | 2.000             |                       | 51.900            | 2     | 42          | 43           |
| 01-017 | 285.000           |                       | 60.000            | 2     | 44          | 88           |
| 01-017 | 25.000            |                       | 75.000            | 2     | 7           | 12           |
| 01-017 | 10.000            |                       | 31.000            | 2     | 20          | 38           |
| 01-017 | 45.000            |                       | 22.000            | 2     | 3           | 12           |
| 01-017 | 300.000           |                       | 29.000            | 2     | 8           | 30           |
| 01-017 | 165.000           |                       | 69.600            | 2     | 6           | 24           |
| 01-017 | 1,140.000         |                       | 34.000            | 2     | 4           | 4            |
| 01-017 | 25.000            |                       | 40.000            | 2     | 3           | 6            |
| 01-017 | 320.000           |                       | 60.000            | 2     | 16          | 33           |
| 01-018 | 60.000            |                       | 43.000            | 2     | 3           | 6            |
| 01-018 | 30.000            |                       | 30.000            | 2     | 2           | 4            |
| 01-018 | 50.000            |                       | 35.000            | 2     | 5           | 11           |
| 01-018 | 30.000            |                       | 22.000            | 2     | 2           | 3            |

# B.1 Potential Duplicate Pump Data

| LAPL   | Capacity<br>(GPM) | Capacity<br>(CFM/CIM) | Pressure<br>(PSI) | APL's | Ship<br>Pop | Fleet<br>Pop |
|--------|-------------------|-----------------------|-------------------|-------|-------------|--------------|
| 01-018 | 20.000            |                       | 50.000            | 2     | 2           | 4            |
| 01-018 | 1,000.000         |                       | 25.000            | 2     | 3           | 9            |
| 01-018 | 400.000           |                       | 30.000            | 2     | 6           | 12           |
| 01-018 | 320.000           |                       | 60.000            | 2     | 44          | 87           |
| 01-018 | 6.000             |                       | 15.000            | 2     | 2           | 8            |
| 01-018 | 400.000           |                       | 15.000            | 2     | 8           | 14           |
| 01-018 | 65.000            |                       | 63.000            | 2     | 32          | 58           |
| 01-018 | 10.000            |                       | 90.000            | 2     | 2           | 3            |
| 01-018 | 260.000           |                       | 70.000            | 2     | 4           | 9            |
| 01-018 | 550.000           |                       | 10.000            | 2     | 15          | 32           |
| 01-018 | 625.000           |                       | 70.000            | 2     | 1           | 8            |
| 01-018 | 25.000            |                       | 50.000            | 2     | 46          | 184          |
| 01-018 | 400.000           |                       | 13.000            | 2     | 1           | 2            |
| 01-018 | 75.000            |                       | 55.000            | 2     | 2           | 4            |
| 01-018 | 60.000            |                       | 50.000            | 2     | 2           | 3            |
| 01-018 | 900.000           |                       | 10.000            | 2     | 1           | 2            |
| 01-018 | 60.000            |                       | 80.000            | 2     | 21          | 61           |
| 01-018 | 275.000           |                       | 75.000            | 2     | 2           | 2            |
| 01-018 | 250.000           |                       | 100.000           | 2     | 6           | 14           |
| 01-018 | 485.000           |                       | 40.000            | 2     | 10          | 19           |
| 01-018 | 3,000.000         |                       | 10.250            | 2     | 6           | 36           |
| 01-018 | 155.000           |                       | 90.000            | 2     | 30          | 30           |
| 01-018 | 25.000            |                       | 40.000            | 2     | 1           | 6            |
| 01-018 | 125.000           |                       | 100.000           | 2     | 4           | 10           |
| 01-018 | 820.000           |                       | 30.000            | 2     | 2           | 5            |
| 01-018 | 700.000           |                       | 15.000            | 2     | 4           | 11           |
| 01-018 | 35.000            |                       | 85.000            | 2     | 1           | 8            |
| 01-018 | 2,500.000         |                       | 13.000            | 2     | 2           | 9            |
| 01-018 | 200.000           |                       | 60.000            | 2     | 2           | 4            |
| 01-018 | 21.000            |                       | 84.000            | 2     | 5           | 11           |
| 01-018 | 80.000            |                       | 50.000            | 2     | 3           | 8            |
| 01-018 | 1,120.000         |                       | 15.000            | 2     | 9           | 33           |
| 01-018 | 200.000           |                       | 35.000            | 2     | 2           | 6            |
| 01-018 | 100.000           |                       | 125.000           | 2     | 3           | 6            |
| 01-018 | 15.000            |                       | 35.000            | 2     | 3           | 6            |
| 01-018 | 22.000            |                       | 65.000            | 2     | 3           | 13           |
| 01-018 | 60.000            |                       | 60.000            | 2     | 9           | 22           |
| 01-018 | 700.000           |                       | 34.000            | 2     | 1           | 3            |
| 01-018 | 110.000           |                       | 56.000            | 2     | 3           | 4            |
| 01-018 | 5.000             |                       | 15.000            | 2     | 5           | 19           |
| 01-018 | 250.000           |                       | 50.000            | 2     | 2           | 3            |
| 01-018 | 10.000            |                       | 25.000            | 2     | 6           | 6            |
| 01-018 | 450.000           |                       | 35.000            | 2     | 4           | 7            |
| 01-018 | 200.000           |                       | 90.000            | 2     | 4           | 16           |
| 01-018 | 40.000            |                       | 60.000            | 2     | 5           | 10           |
| 01-018 | 100.000           |                       | 75.000            | 2     | 3           | 12           |
| 01-018 | 270.000           |                       | 25.000            | 2     | 49          | 99           |

# B.1 Potential Duplicate Pump Data

| LAPL   | Capacity<br>(GPM) | Capacity<br>(CFM/CIM) | Pressure<br>(PSI) | APL's | Ship<br>Pop | Fleet<br>Pop |
|--------|-------------------|-----------------------|-------------------|-------|-------------|--------------|
| 01-018 | 75.000            |                       | 75.000            | 2     | 3           | 10           |
| 01-018 | 15.000            |                       | 30.000            | 2     | 5           | 10           |
| 01-018 | 175.000           |                       | 36.000            | 2     | 2           | 12           |
| 01-018 | 210.000           |                       | 75.000            | 2     | 3           | 16           |
| 01-018 | 5.000             |                       | 5.000             | 2     | 3           | 18           |
| 01-018 | 125.000           |                       | 65.000            | 2     | 4           | 7            |
| 01-018 | 100.000           |                       | 15.000            | 2     | 4           | 4            |
| 01-018 | 110.000           |                       | 115.000           | 2     | 6           | 12           |
| 01-018 | 250.000           |                       | 34.000            | 2     | 3           | 5            |
| 01-018 | 1,800.000         |                       | 15.000            | 2     | 9           | 38           |
| 01-018 | 175.000           |                       | 32.000            | 2     | 1           | 4            |
| 01-019 | 10.000            |                       | 30.000            | 2     | 4           | 18           |
| 01-019 | 4.000             |                       | 108.000           | 2     | 11          | 17           |
| 01-019 | 4.000             |                       | 60.000            | 2     | 1           | 3            |
| 01-028 | 250.000           |                       | 760.000           | 2     | 3           | 3            |
| 01-034 | 0.000             |                       | 4,500.000         | 2     | 13          | 29           |
| 01-035 | 875.000           |                       | 120.000           | 2     | 9           | 18           |
| 01-035 | 3,000.000         |                       | 150.000           | 2     | 2           | 12           |
| 01-035 | 6,000.000         |                       | 150.000           | 2     | 2           | 6            |
| 01-037 | 0.300             |                       | 4,500.000         | 2     | 9           | 14           |
| 01-038 | 4.000             |                       | 6,000.000         | 2     | 4           | 18           |
| 01-038 | 180.000           |                       | 72.000            | 2     | 16          | 26           |
| 01-038 | 40.000            |                       | 60.000            | 2     | 3           | 5            |
| 01-038 | 38.000            |                       | 30.000            | 2     | 4           | 4            |
| 01-001 | 555.000           |                       | 1,350.000         | 3     | 4           | 48           |
| 01-002 | 700.000           |                       | 100.000           | 3     | 1           | 6            |
| 01-002 | 200.000           |                       | 760.000           | 3     | 15          | 14           |
| 01-002 | 200.000           |                       | 800.000           | 3     | 30          | 35           |
| 01-002 | 200.000           |                       | 125.000           | 3     | 10          | 21           |
| 01-003 | 3,200.000         |                       | 16.000            | 3     | 2           | 6            |
| 01-005 | 10.000            |                       | 50.000            | 3     | 49          | 50           |
| 01-005 | 15.000            |                       | 1,100.000         | 3     | 50          | 118          |
| 01-005 | 38.000            |                       | 3,000.000         | 3     | 40          | 169          |
| 01-005 | 250.000           |                       | 150.000           | 3     | 27          | 58           |
| 01-005 | 415.000           |                       | 50.000            | 3     | 9           | 28           |
| 01-005 | 750.000           |                       | 55.000            | 3     | 35          | 97           |
| 01-005 | 900.000           |                       | 50.000            | 3     | 1           | 3            |
| 01-005 | 55.000            |                       | 90.000            | 3     | 18          | 78           |
| 01-007 | 60.000            |                       | 100.000           | 3     | 6           | 8            |
| 01-007 | 25.000            |                       | 25.000            | 3     | 10          | 15           |
| 01-007 | 200.000           |                       | 100.000           | 3     | 7           | 10           |
| 01-007 | 50.000            |                       | 50.000            | 3     | 3           | 9            |
| 01-007 | 6.000             |                       | 18.000            | 3     | 13          | 51           |
| 01-008 | 25.000            |                       | 50.000            | 3     | 21          | 56           |
| 01-008 | 10.000            |                       | 32.500            | 3     | 112         | 111          |
| 01-009 | 5.000             |                       | 2,000.000         | 3     | 16          | 57           |
| 01-009 | 5.000             |                       | 1,000.000         | 3     | 8           | 14           |

# B.1 Potential Duplicate Pump Data

| LAPL   | Capacity<br>(GPM) | Capacity<br>(CFM/CIM) | Pressure<br>(PSI) | APL's | Ship<br>Pop | Fleet<br>Pop |
|--------|-------------------|-----------------------|-------------------|-------|-------------|--------------|
| 01-009 | 15.000            |                       | 50.000            | 3     | 52          | 95           |
| 01-009 | 60.000            |                       | 190.000           | 3     | 6           | 56           |
| 01-009 | 65.000            |                       | 175.000           | 3     | 68          | 393          |
| 01-009 | 11.000            |                       | 1,000.000         | 3     | 12          | 15           |
| 01-009 | 8.000             |                       | 2,000.000         | 3     | 15          | 31           |
| 01-009 | 10.000            |                       | 1,000.000         | 3     | 2           | 5            |
| 01-010 | 29.000            |                       | 3,000.000         | 3     | 7           | 42           |
| 01-010 | 58.700            |                       | 3,000.000         | 3     | 11          | 22           |
| 01-010 | 120.000           |                       | 3,000.000         | 3     | 4           | 16           |
| 01-010 | 20.000            |                       | 5,000.000         | 3     | 5           | 8            |
| 01-010 | 88.000            |                       | 4,500.000         | 3     | 7           | 6            |
| 01-010 | 114.000           |                       | 3,000.000         | 3     | 4           | 9            |
| 01-010 | 303.000           |                       | 3,000.000         | 3     | 2           | 7            |
| 01-010 | 120.000           |                       | 5,000.000         | 3     | 8           | 41           |
| 01-010 | 10.000            |                       | 1,500.000         | 3     | 8           | 28           |
| 01-011 | 400.000           |                       | 20.000            | 3     | 1           | 6            |
| 01-011 | 500.000           |                       | 100.000           | 3     | 16          | 22           |
| 01-011 | 40.000            |                       | 7.500             | 3     | 7           | 10           |
| 01-011 | 35.000            |                       | 35.000            | 3     | 12          | 31           |
| 01-011 | 50.000            |                       | 30.000            | 3     | 4           | 11           |
| 01-011 | 10.000            |                       | 4.000             | 3     | 10          | 32           |
| 01-011 | 70.000            |                       | 150.000           | 3     | 4           | 12           |
| 01-011 | 400.000           |                       | 40.000            | 3     | 50          | 219          |
| 01-011 | 15.000            |                       | 30.000            | 3     | 1           | 9            |
| 01-011 | 2,000.000         |                       | 150.000           | 3     | 8           | 18           |
| 01-011 | 500.000           |                       | 50.000            | 3     | 23          | 48           |
| 01-011 | 300.000           |                       | 75.000            | 3     | 3           | 6            |
| 01-011 | 600.000           |                       | 34.000            | 3     | 6           | 12           |
| 01-011 | 180.000           |                       | 60.000            | 3     | 5           | 10           |
| 01-011 | 55.000            |                       | 23.000            | 3     | 309         | 390          |
| 01-011 | 300.000           |                       | 25.000            | 3     | 5           | 10           |
| 01-011 | 400.000           |                       | 121.000           | 3     | 1           | 3            |
| 01-011 | 1,000.000         |                       | 147.000           | 3     | 14          | 41           |
| 01-011 | 800.000           |                       | 50.000            | 3     | 10          | 26           |
| 01-011 | 1,350.000         |                       | 100.000           | 3     | 4           | 10           |
| 01-011 | 1,575.000         |                       | 25.000            | 3     | 4           | 28           |
| 01-011 | 20.000            |                       | 20.000            | 3     | 83          | 115          |
| 01-011 | 10.000            |                       | 40.000            | 3     | 47          | 99           |
| 01-011 | 500.000           |                       | 20.000            | 3     | 2           | 6            |
| 01-011 | 1,100.000         |                       | 336.000           | 3     | 18          | 101          |
| 01-011 | 50.000            |                       | 50.000            | 3     | 7           | 11           |
| 01-011 | 630.000           |                       | 55.000            | 3     | 10          | 10           |
| 01-011 | 400.000           |                       | 125.000           | 3     | 1           | 6            |
| 01-011 | 250.000           |                       | 100.000           | 3     | 4           | 7            |
| 01-011 | 50.000            |                       | 22.000            | 3     | 11          | 25           |
| 01-011 | 550.000           |                       | 30.000            | 3     | 4           | 14           |
| 01-011 | 350.000           |                       | 30.000            | 3     | 2           | 7            |

# B.1 Potential Duplicate Pump Data

| LAPL   | Capacity<br>(GPM) | Capacity<br>(CFM/CIM) | Pressure<br>(PSI) | APL's | Ship<br>Pop | Fleet<br>Pop |
|--------|-------------------|-----------------------|-------------------|-------|-------------|--------------|
| 01-011 | 400.000           |                       | 45.000            | 3     | 2           | 41           |
| 01-011 | 12.000            |                       | 35.000            | 3     | 40          | 41           |
| 01-011 | 150.000           |                       | 90.000            | 3     | 36          | 76           |
| 01-011 | 2,200.000         |                       | 40.000            | 3     | 3           | 4            |
| 01-011 | 40.000            |                       | 20.000            | 3     | 8           | 8            |
| 01-011 | 200.000           |                       | 50.000            | 3     | 17          | 38           |
| 01-011 | 150.000           |                       | 25.000            | 3     | 21          | 37           |
| 01-011 | 25.000            |                       | 60.000            | 3     | 4           | 9            |
| 01-014 | 15.000            |                       | 25.000            | 3     | 24          | 47           |
| 01-014 | 30.000            |                       | 22.000            | 3     | 7           | 11           |
| 01-014 | 0.000             | 4.500                 | 325.000           | 3     | 3           | 31           |
| 01-014 | 6.000             |                       | 15.000            | 3     | 20          | 51           |
| 01-014 | 0.000             | 1.250                 | 1,500.000         | 3     | 25          | 72           |
| 01-014 | 14.000            |                       | 15.000            | 3     | 16          | 54           |
| 01-014 | 5.000             |                       | 22.000            | 3     | 124         | 923          |
| 01-014 | 5.000             |                       | 20.000            | 3     | 17          | 119          |
| 01-017 | 700.000           |                       | 50.000            | 3     | 2           | 14           |
| 01-017 | 8.000             |                       | 50.000            | 3     | 29          | 57           |
| 01-017 | 8.000             |                       | 42.000            | 3     | 44          | 44           |
| 01-017 | 10.000            |                       | 22.000            | 3     | 3           | 6            |
| 01-017 | 630.000           |                       | 65.000            | 3     | 18          | 37           |
| 01-017 | 15.000            |                       | 70.000            | 3     | 22          | 46           |
| 01-017 | 325.000           |                       | 80.000            | 3     | 8           | 17           |
| 01-017 | 150.000           |                       | 85.000            | 3     | 7           | 22           |
| 01-017 | 2.000             |                       | 25.000            | 3     | 51          | 51           |
| 01-017 | 8.000             |                       | 41.000            | 3     | 32          | 32           |
| 01-017 | 250.000           |                       | 41.000            | 3     | 4           | 18           |
| 01-017 | 25.000            |                       | 30.000            | 3     | 15          | 28           |
| 01-017 | 720.000           |                       | 90.000            | 3     | 5           | 80           |
| 01-017 | 60.000            |                       | 70.000            | 3     | 22          | 53           |
| 01-017 | 50.000            |                       | 50.000            | 3     | 4           | 8            |
| 01-017 | 10.000            |                       | 35.000            | 3     | 10          | 22           |
| 01-017 | 100.000           |                       | 34.000            | 3     | 3           | 3            |
| 01-017 | 15.000            |                       | 75.000            | 3     | 13          | 27           |
| 01-017 | 17.000            |                       | 55.000            | 3     | 5           | 9            |
| 01-018 | 70.000            |                       | 50.000            | 3     | 26          | 54           |
| 01-018 | 100.000           |                       | 43.000            | 3     | 5           | 11           |
| 01-018 | 180.000           |                       | 72.000            | 3     | 33          | 48           |
| 01-018 | 150.000           |                       | 60.000            | 3     | 2           | 7            |
| 01-018 | 450.000           |                       | 50.000            | 3     | 13          | 30           |
| 01-018 | 50.000            |                       | 60.000            | 3     | 26          | 59           |
| 01-018 | 500.000           |                       | 35.000            | 3     | 8           | 32           |
| 01-018 | 150.000           |                       | 65.000            | 3     | 12          | 22           |
| 01-018 | 40.000            |                       | 20.000            | 3     | 50          | 50           |
| 01-018 | 175.000           |                       | 50.000            | 3     | 10          | 10           |
| 01-018 | 10.000            |                       | 95.000            | 3     | 6           | 19           |
| 01-018 | 200.000           |                       | 100.000           | 3     | 5           | 15           |

# B.1 Potential Duplicate Pump Data

| LAPL   | Capacity<br>(GPM) | Capacity<br>(CFM/CIM) | Pressure<br>(PSI) | APL's | Ship<br>Pop | Fleet<br>Pop |
|--------|-------------------|-----------------------|-------------------|-------|-------------|--------------|
| 01-018 | 125.000           |                       | 60.000            | 3     | 12          | 24           |
| 01-018 | 50.000            |                       | 48.000            | 3     | 2           | 3            |
| 01-018 | 115.000           |                       | 50.000            | 3     | 7           | 14           |
| 01-018 | 10.000            |                       | 50.000            | 3     | 4           | 10           |
| 01-001 | 250.000           |                       | 760.000           | 4     | 13          | 37           |
| 01-001 | 300.000           |                       | 471.000           | 4     | 11          | 38           |
| 01-002 | 50.000            |                       | 50.000            | 4     | 10          | 14           |
| 01-003 | 4,900.000         |                       | 24.000            | 4     | 6           | 12           |
| 01-003 | 5,600.000         |                       | 19.000            | 4     | 5           | 14           |
| 01-005 | 18.000            |                       | 1,300.000         | 4     | 49          | 117          |
| 01-005 | 60.000            |                       | 100.000           | 4     | 20          | 88           |
| 01-005 | 80.000            |                       | 1,140.000         | 4     | 31          | 133          |
| 01-005 | 500.000           |                       | 150.000           | 4     | 47          | 1151         |
| 01-005 | 375.000           |                       | 50.000            | 4     | 33          | 66           |
| 01-005 | 700.000           |                       | 60.000            | 4     | 54          | 194          |
| 01-005 | 15.000            |                       | 350.000           | 4     | 53          | 68           |
| 01-008 | 22.000            |                       | 50.000            | 4     | 20          | 197          |
| 01-009 | 400.000           |                       | 150.000           | 4     | 14          | 45           |
| 01-009 | 60.000            |                       | 50.000            | 4     | 49          | 148          |
| 01-009 | 25.000            |                       | 25.000            | 4     | 79          | 87           |
| 01-010 | 20.000            |                       | 2,000.000         | 4     | 7           | 29           |
| 01-010 | 45.000            |                       | 1,500.000         | 4     | 2           | 7            |
| 01-010 | 110.000           |                       | 1,775.000         | 4     | 10          | 58           |
| 01-010 | 20.000            |                       | 1,500.000         | 4     | 25          | 34           |
| 01-010 | 15.000            |                       | 3,000.000         | 4     | 23          | 50           |
| 01-011 | 100.000           |                       | 150.000           | 4     | 16          | 48           |
| 01-011 | 220.000           |                       | 30.000            | 4     | 13          | 30           |
| 01-011 | 100.000           |                       | 24.000            | 4     | 5           | 20           |
| 01-011 | 155.000           |                       | 100.000           | 4     | 19          | 19           |
| 01-011 | 200.000           |                       | 35.000            | 4     | 12          | 25           |
| 01-011 | 30.000            |                       | 60.000            | 4     | 9           | 22           |
| 01-011 | 400.000           |                       | 36.000            | 4     | 5           | 20           |
| 01-011 | 1,000.000         |                       | 146.000           | 4     | 11          | 29           |
| 01-011 | 200.000           |                       | 70.000            | 4     | 15          | 54           |
| 01-011 | 300.000           |                       | 125.000           | 4     | 7           | 14           |
| 01-011 | 100.000           |                       | 100.000           | 4     | 4           | 6            |
| 01-011 | 600.000           |                       | 30.000            | 4     | 21          | 49           |
| 01-011 | 650.000           |                       | 80.000            | 4     | 8           | 58           |
| 01-011 | 10.000            |                       | 25.000            | 4     | 2           | 5            |
| 01-011 | 20.000            |                       | 50.000            | 4     | 25          | 28           |
| 01-011 | 28.000            |                       | 51.000            | 4     | 82          | 192          |
| 01-011 | 750.000           |                       | 125.000           | 4     | 5           | 6            |
| 01-011 | 50.000            |                       | 65.000            | 4     | 235         | 442          |
| 01-011 | 500.000           |                       | 146.000           | 4     | 7           | 13           |
| 01-011 | 30.000            |                       | 15.000            | 4     | 6           | 12           |
| 01-014 | 10.000            |                       | 26.000            | 4     | 11          | 13           |
| 01-014 | 5.000             |                       | 15.000            | 4     | 117         | 167          |

# B.1 Potential Duplicate Pump Data

| LAPL   | Capacity<br>(GPM) | Capacity<br>(CFM/CIM) | Pressure<br>(PSI) | APL's | Ship<br>Pop | Fleet<br>Pop |
|--------|-------------------|-----------------------|-------------------|-------|-------------|--------------|
| 01-014 | 0.850             |                       | 500.000           | 4     | 22          | 84           |
| 01-017 | 40.000            |                       | 70.000            | 4     | 50          | 204          |
| 01-017 | 520.000           |                       | 65.000            | 4     | 5           | 26           |
| 01-017 | 18.000            |                       | 40.000            | 4     | 28          | 57           |
| 01-017 | 165.000           |                       | 70.000            | 4     | 20          | 82           |
| 01-017 | 35.000            |                       | 75.000            | 4     | 11          | 40           |
| 01-017 | 100.000           |                       | 35.000            | 4     | 3           | 6            |
| 01-017 | 3.500             |                       | 37.300            | 4     | 34          | 34           |
| 01-017 | 15.000            |                       | 50.000            | 4     | 11          | 24           |
| 01-018 | 150.000           |                       | 50.000            | 4     | 4           | 12           |
| 01-018 | 10.000            |                       | 15.000            | 4     | 9           | 33           |
| 01-018 | 170.000           |                       | 45.000            | 4     | 89          | 174          |
| 01-018 | 15.000            |                       | 50.000            | 4     | 49          | 53           |
| 01-018 | 100.000           |                       | 130.000           | 4     | 22          | 43           |
| 01-018 | 12.000            |                       | 50.000            | 4     | 9           | 17           |
| 01-018 | 15.000            |                       | 25.000            | 4     | 20          | 23           |
| 01-018 | 160.000           |                       | 50.000            | 4     | 26          | 72           |
| 01-018 | 200.000           |                       | 30.000            | 4     | 19          | 37           |
| 01-018 | 900.000           |                       | 20.000            | 4     | 7           | 14           |
| 01-018 | 2,200.000         |                       | 10.000            | 4     | 3           | 32           |
| 01-018 | 2,200.000         |                       | 12.000            | 4     | 5           | 12           |
| 01-018 | 200.000           |                       | 70.000            | 4     | 9           | 17           |
| 01-018 | 125.000           |                       | 35.000            | 4     | 5           | 10           |
| 01-018 | 15.000            |                       | 40.000            | 4     | 37          | 39           |
| 01-018 | 40.000            |                       | 40.000            | 4     | 33          | 66           |
| 01-042 | 250.000           |                       | 100.000           | 4     | 507         | 1948         |
| 01-001 | 300.000           |                       | 476.000           | 5     | 23          | 85           |
| 01-005 | 25.000            |                       | 50.000            | 5     | 26          | 48           |
| 01-005 | 400.000           |                       | 55.000            | 5     | 28          | 58           |
| 01-005 | 700.000           |                       | 150.000           | 5     | 15          | 59           |
| 01-005 | 35.000            |                       | 400.000           | 5     | 25          | 54           |
| 01-005 | 100.000           |                       | 50.000            | 5     | 69          | 118          |
| 01-005 | 650.000           |                       | 50.000            | 5     | 4           | 15           |
| 01-009 | 50.000            |                       | 15.000            | 5     | 11          | 34           |
| 01-009 | 50.000            |                       | 90.000            | 5     | 59          | 108          |
| 01-009 | 100.000           |                       | 50.000            | 5     | 64          | 76           |
| 01-010 | 20.000            |                       | 3,000.000         | 5     | 22          | 43           |
| 01-010 | 110.000           |                       | 3,000.000         | 5     | 55          | 108          |
| 01-010 | 15.000            |                       | 1,500.000         | 5     | 31          | 39           |
| 01-010 | 90.000            |                       | 2,000.000         | 5     | 12          | 49           |
| 01-010 | 202.000           |                       | 2,000.000         | 5     | 7           | 24           |
| 01-011 | 3,000.000         |                       | 150.000           | 5     | 6           | 47           |
| 01-011 | 5.000             |                       | 5.000             | 5     | 83          | 334          |
| 01-011 | 20.000            |                       | 30.000            | 5     | 15          | 29           |
| 01-011 | 25.000            |                       | 50.000            | 5     | 6           | 12           |
| 01-011 | 57.000            |                       | 50.000            | 5     | 32          | 66           |
| 01-011 | 80.000            |                       | 5.000             | 5     | 247         | 573          |



# B.1 Potential Duplicate Pump Data

| LAPL   | Capacity<br>(GPM) | Capacity<br>(CFM/CIM) | Pressure<br>(PSI) | APL's | Ship<br>Pop | Fleet<br>Pop |
|--------|-------------------|-----------------------|-------------------|-------|-------------|--------------|
| 01-011 | 15.000            |                       | 40.000            | 5     | 44          | 56           |
| 01-011 | 600.000           |                       | 100.000           | 5     | 4           | 29           |
| 01-011 | 10.000            |                       | 50.000            | 5     | 10          | 22           |
| 01-011 | 100.000           |                       | 50.000            | 5     | 68          | 119          |
| 01-011 | 50.000            |                       | 40.000            | 5     | 142         | 329          |
| 01-014 | 30.000            |                       | 15.000            | 5     | 32          | 63           |
| 01-014 | 1.560             |                       | 300.000           | 5     | 12          | 34           |
| 01-017 | 20.000            |                       | 22.000            | 5     | 5           | 9            |
| 01-017 | 280.000           |                       | 30.000            | 5     | 17          | 51           |
| 01-017 | 50.000            |                       | 55.000            | 5     | 6           | 20           |
| 01-017 | 595.000           |                       | 65.000            | 5     | 7           | 56           |
| 01-018 | 500.000           |                       | 50.000            | 5     | 60          | 157          |
| 01-018 | 50.000            |                       | 50.000            | 5     | 4           | 10           |
| 01-018 | 75.000            |                       | 60.000            | 5     | 19          | 81           |
| 01-018 | 100.000           |                       | 70.000            | 5     | 15          | 33           |
| 01-018 | 300.000           |                       | 50.000            | 5     | 9           | 17           |
| 01-018 | 135.000           |                       | 30.000            | 5     | 7           | 11           |
| 01-018 | 200.000           |                       | 50.000            | 5     | 16          | 26           |
| 01-018 | 40.000            |                       | 50.000            | 5     | 110         | 221          |
| 01-001 | 300.000           |                       | 468.000           | 6     | 41          | 168          |
| 01-003 | 5,300.000         |                       | 19.000            | 6     | 37          | 77           |
| 01-005 | 50.000            |                       | 50.000            | 6     | 17          | 47           |
| 01-005 | 40.000            |                       | 3,000.000         | 6     | 70          | 293          |
| 01-005 | 15.000            |                       | 25.000            | 6     | 49          | 58           |
| 01-009 | 25.000            |                       | 50.000            | 6     | 42          | 57           |
| 01-009 | 100.000           |                       | 15.000            | 6     | 17          | 308          |
| 01-009 | 50.000            |                       | 100.000           | 6     | 16          | 42           |
| 01-009 | 50.000            |                       | 60.000            | 6     | 183         | 441          |
| 01-010 | 122.000           |                       | 4,500.000         | 6     | 16          | 22           |
| 01-010 | 122.000           |                       | 3,500.000         | 6     | 14          | 24           |
| 01-011 | 750.000           |                       | 50.000            | 6     | 8           | 22           |
| 01-011 | 600.000           |                       | 60.000            | 6     | 6           | 23           |
| 01-011 | 40.000            |                       | 25.000            | 6     | 21          | 36           |
| 01-011 | 400.000           |                       | 100.000           | 6     | 7           | 15           |
| 01-011 | 150.000           |                       | 22.000            | 6     | 26          | 62           |
| 01-014 | 0.000             | 0.750                 | 3,000.000         | 6     | 161         | 1148         |
| 01-014 | 0.000             | 1.500                 | 1,500.000         | 6     | 126         | 288          |
| 01-017 | 30.000            |                       | 35.000            | 6     | 13          | 19           |
| 01-018 | 75.000            |                       | 50.000            | 6     | 12          | 44           |
| 01-018 | 25.000            |                       | 60.000            | 6     | 5           | 17           |
| 01-011 | 750.000           |                       | 150.000           | 7     | 18          | 39           |
| 01-011 | 600.000           |                       | 75.000            | 7     | 12          | 26           |
| 01-017 | 240.000           |                       | 75.000            | 7     | 16          | 31           |
| 01-017 | 60.000            |                       | 80.000            | 7     | 11          | 34           |
| 01-018 | 30.000            |                       | 50.000            | 7     | 12          | 31           |
| 01-002 | 100.000           |                       | 50.000            | 8     | 101         | 120          |
| 01-003 | 5,300.000         |                       | 19.300            | 8     | 36          | 73           |

# B.1 Potential Duplicate Pump Data

| LAPL   | Capacity<br>(GPM) | Capacity<br>(CFM/CIM) | Pressure<br>(PSI) | APL's | Ship<br>Pop | Fleet<br>Pop |
|--------|-------------------|-----------------------|-------------------|-------|-------------|--------------|
| 01-005 | 300.000           |                       | 50.000            | 8     | 20          | 33           |
| 01-007 | 25.000            |                       | 50.000            | 8     | 18          | 34           |
| 01-009 | 200.000           |                       | 50.000            | 8     | 67          | 174          |
| 01-009 | 200.000           |                       | 100.000           | 8     | 20          | 56           |
| 01-010 | 10.000            |                       | 3,000.000         | 8     | 111         | 181          |
| 01-011 | 250.000           |                       | 25.000            | 8     | 44          | 62           |
| 01-011 | 1,000.000         |                       | 175.000           | 8     | 15          | 204          |
| 01-011 | 500.000           |                       | 150.000           | 8     | 23          | 66           |
| 01-011 | 2,000.000         |                       | 175.000           | 8     | 17          | 83           |
| 01-011 | 1,000.000         |                       | 125.000           | 8     | 27          | 56           |
| 01-011 | 1,100.000         |                       | 150.000           | 8     | 17          | 114          |
| 01-011 | 600.000           |                       | 35.000            | 8     | 10          | 19           |
| 01-020 | 3,000.000         |                       | 150.000           | 8     | 8           | 75           |
| 01-010 | 202.000           |                       | 3,000.000         | 9     | 25          | 83           |
| 01-010 | 200.000           |                       | 3,000.000         | 9     | 79          | 290          |
| 01-011 | 15.000            |                       | 25.000            | 9     | 59          | 65           |
| 01-009 | 50.000            |                       | 75.000            | 10    | 83          | 169          |
| 01-010 | 88.000            |                       | 3,000.000         | 10    | 58          | 88           |
| 01-005 | 400.000           |                       | 50.000            | 11    | 23          | 53           |
| 01-010 | 45.000            |                       | 3,000.000         | 11    | 29          | 63           |
| 01-010 | 5.000             |                       | 3,000.000         | 12    | 42          | 153          |
| 01-010 | 90.000            |                       | 3,000.000         | 13    | 74          | 252          |
| 01-011 | 900.000           |                       | 125.000           | 17    | 82          | 306          |
| 01-011 | 500.000           |                       | 125.000           | 18    | 77          | 332          |
| 01-009 | 50.000            |                       | 50.000            | 22    | 136         | 300          |
| 01-010 | 122.000           |                       | 3,000.000         | 34    | 62          | 145          |
| 01-011 | 1,000.000         |                       | 150.000           | 41    | 100         | 523          |

## B.2 Duplicate Percentages

| Equipment<br>Per APL       | Frequency | Potential<br>Duplicates |
|----------------------------|-----------|-------------------------|
| 2                          | 447       | 89                      |
| 3                          | 121       | 36                      |
| 4                          | 69        | 69                      |
| 5                          | 40        | 50                      |
| 6                          | 21        | 32                      |
| 7                          | 5         | 9                       |
| 8                          | 15        | 30                      |
| 9                          | 3         | 7                       |
| 10                         | 2         | 5                       |
| 11                         | 2         | 6                       |
| 12                         | 1         | 3                       |
| 13                         | 1         | 3                       |
| 17                         | 1         | 4                       |
| 18                         | 1         | 5                       |
| 22                         | 1         | 6                       |
| 34                         | 1         | 9                       |
| 41                         | 1         | 10                      |
| Total Potential Duplicates |           | 373                     |

## **APPENDIX C : DUPLICATE APL'S AND PARTS**

Appendix C provides the estimates of the potential number of duplicates on a commodity basis. The method used to estimate these numbers was described in Chapter III. The tables are presented in two parts. The first part provides the potential duplicate APL's and parts that are currently in the Navy Supply System as well as the number of duplicate equipments and parts entering the Navy inventory in 1987. The second portion of the table provides the data for 1988 and 1989.

Potential Duplicate APL's and Parts

| Nomenclature       | Total<br>APL's | Potential<br>Duplicate<br>APL's | Initial Potential<br>Parts Reduction | 1987 Potential<br>APL Reduction | 1987 Potential<br>Parts Reduction |
|--------------------|----------------|---------------------------------|--------------------------------------|---------------------------------|-----------------------------------|
| PUMPS              | 7,400          | 373                             | 1,585                                | 24                              | 103                               |
| BOILERS            | 198            | 10                              | 235                                  | 0                               | 9                                 |
| HEAT EXCHANGERS    | 1,675          | 34                              | 169                                  | 3                               | 6                                 |
| CONDENSERS         | 797            | 40                              | 90                                   | 1                               | 1                                 |
| TURBINES           | 905            | 46                              | 1,289                                | 1                               | 27                                |
| COMPRESSORS        | 808            | 41                              | 784                                  | 3                               | 57                                |
| HEATERS            | 2,523          | 127                             | 159                                  | 9                               | 11                                |
| DISTILLING PLANTS  | 320            | 16                              | 65                                   | 1                               | 2                                 |
| BATTERY CHANGERS   | 290            | 15                              | 55                                   | 1                               | 5                                 |
| METERS             | 439            | 22                              | 17                                   | 1                               | 1                                 |
| CONVERTERS         | 657            | 33                              | 190                                  | 2                               | 12                                |
| TRANSFORMERS       | 378            | 44                              | 11                                   | 0                               | 0                                 |
| CIRCUIT BREAKERS   | 3,971          | 200                             | 500                                  | 8                               | 19                                |
| CONTROLLERS        | 11,312         | 595                             | 2,382                                | 44                              | 178                               |
| GENERATORS         | 704            | 35                              | 151                                  | 4                               | 16                                |
| MOTORS             | 14,014         | 706                             | 383                                  | 49                              | 62                                |
| MOTOR GENERATORS   | 351            | 18                              | 53                                   | 0                               | 1                                 |
| RELAYS             | 1,543          | 78                              | 37                                   | 3                               | 4                                 |
| RHEOSTATS          | 509            | 26                              | 32                                   | 0                               | 0                                 |
| SWITCHES           | 9,260          | 467                             | 467                                  | 23                              | 23                                |
| SWITCHBOARDS       | 2,839          | 143                             | 537                                  | 4                               | 14                                |
| VISUAL ALARMS      | 615            | 31                              | 46                                   | 1                               | 1                                 |
| LIGHTING FIXTURES  | 1,035          | 52                              | 65                                   | 2                               | 2                                 |
| GYRO COMPASSES     | 806            | 41                              | 386                                  | 1                               | 10                                |
| PROJECTION EQUIP   | 54             | 3                               | 52                                   | 0                               | 2                                 |
| I/C EQUIP          | 1,286          | 65                              | 259                                  | 2                               | 9                                 |
| NAVIGATIONAL EQUIP | 322            | 16                              | 183                                  | 2                               | 21                                |
| INJECTORS          | 71             | 4                               | 23                                   | 0                               | 1                                 |
| BURNERS            | 109            | 5                               | 49                                   | 0                               | 2                                 |
| MARINE HARDWARE    | 1,573          | 79                              | 159                                  | 2                               | 4                                 |
| REFRIG EQUIP       | 3,407          | 172                             | 429                                  | 22                              | 55                                |
| AIR CONDITIONING   | 206            | 10                              | 34                                   | 1                               | 4                                 |
| STARTERS           | 216            | 11                              | 32                                   | 1                               | 5                                 |
| WIPERS             | 178            | 9                               | 31                                   | 0                               | 1                                 |
| AUDIBLE ALARMS     | 99             | 5                               | 12                                   | 1                               | 1                                 |
| BEARINGS           | 632            | 32                              | 40                                   | 1                               | 1                                 |
| INDICATORS         | 2,192          | 110                             | 276                                  | 8                               | 20                                |
| CLUTCHES           | 146            | 7                               | 35                                   | 0                               | 2                                 |
| FANS               | 2,292          | 116                             | 58                                   | 5                               | 2                                 |
| SHOP EQUIP         | 3,208          | 162                             | 323                                  | 11                              | 22                                |
| REGULATORS         | 384            | 45                              | 201                                  | 1                               | 5                                 |
| GALLEY EQUIP       | 2,142          | 108                             | 351                                  | 10                              | 33                                |
| DEHYDRATORS        | 247            | 12                              | 58                                   | 1                               | 4                                 |
| SAGES              | 3,252          | 164                             | 205                                  | 7                               | 8                                 |
| TESTING EQUIP      | 637            | 32                              | 128                                  | 3                               | 14                                |
| FILTERS            | 3,563          | 180                             | 449                                  | 10                              | 25                                |
| PANELS             | 4,265          | 215                             | 645                                  | 11                              | 34                                |

Potential Duplicate APL's and Parts

| Nomenclature           | Total<br>APL's | Potential<br>Duplicate APL's | Initial Potential<br>Parts Reduction | 1987 Potential<br>APL Reduction | 1987 Potential<br>Parts Reduction |
|------------------------|----------------|------------------------------|--------------------------------------|---------------------------------|-----------------------------------|
| ISOLATORS              | 20             | 1                            | 2                                    | 0                               | 0                                 |
| HYDRAULIC EQUIP        | 1,368          | 69                           | 396                                  | 10                              | 57                                |
| CAPSTANS               | 140            | 7                            | 26                                   | 0                               | 1                                 |
| REELS                  | 306            | 15                           | 50                                   | 2                               | 5                                 |
| DAVITS                 | 191            | 10                           | 17                                   | 0                               | 0                                 |
| CRANES                 | 307            | 15                           | 139                                  | 1                               | 5                                 |
| HOISTS                 | 717            | 36                           | 172                                  | 2                               | 8                                 |
| ELEVATORS              | 740            | 37                           | 242                                  | 1                               | 4                                 |
| STEERING EQUIP         | 132            | 7                            | 95                                   | 0                               | 4                                 |
| CONTROL EQUIP          | 6,785          | 342                          | 1,111                                | 17                              | 56                                |
| WINCHES                | 742            | 37                           | 243                                  | 3                               | 19                                |
| WINDLASSES             | 162            | 8                            | 71                                   | 0                               | 2                                 |
| FIREFIGHTING EQUIP     | 345            | 17                           | 83                                   | 3                               | 14                                |
| LUBRICATORS            | 253            | 13                           | 32                                   | 1                               | 2                                 |
| ENGINES                | 506            | 26                           | 2,780                                | 2                               | 231                               |
| PLUMBING EQUIP         | 259            | 13                           | 29                                   | 1                               | 1                                 |
| GEARS AND REDUCERS     | 1,349          | 68                           | 493                                  | 3                               | 18                                |
| GOVERNORS              | 390            | 20                           | 339                                  | 3                               | 46                                |
| IGNITION EQUIP         | 4              | 0                            | 1                                    | 0                               | 0                                 |
| EJECTORS               | 415            | 21                           | 78                                   | 0                               | 1                                 |
| EDUCTORS               | 369            | 19                           | 9                                    | 0                               | 0                                 |
| STRAINERS              | 4,191          | 211                          | 158                                  | 5                               | 4                                 |
| PURIFIERS              | 267            | 13                           | 316                                  | 1                               | 31                                |
| TRAPS-STEAM            | 1,014          | 51                           | 51                                   | 1                               | 1                                 |
| COUPLINGS              | 942            | 47                           | 47                                   | 4                               | 4                                 |
| SILENCING EQUIP        | 161            | 8                            | 6                                    | 0                               | 0                                 |
| BRAKES                 | 828            | 42                           | 63                                   | 2                               | 3                                 |
| BLOWERS                | 240            | 12                           | 148                                  | 0                               | 6                                 |
| WELDING SYSTEMS        | 367            | 18                           | 88                                   | 2                               | 9                                 |
| BOAT PROPULSION        | 909            | 46                           | 80                                   | 1                               | 2                                 |
| DECK MACHINERY         | 1,663          | 84                           | 231                                  | 2                               | 7                                 |
| PHOTOGRAPHIC EQUIP     | 72             | 4                            | 11                                   | 0                               | 0                                 |
| UNDERWATER LOG EQUIP   | 207            | 10                           | 78                                   | 0                               | 1                                 |
| VALVES                 | 59,254         | 2,987                        | 4,480                                | 99                              | 149                               |
| MISC PARTS             | 2,398          | 121                          | 1,934                                | 11                              | 183                               |
| LAUNDRY EQUIP          | 561            | 28                           | 198                                  | 12                              | 86                                |
| TANKS                  | 764            | 39                           | 48                                   | 1                               | 1                                 |
| PIPE, HOSE, & FITTINGS | 139            | 7                            | 7                                    | 0                               | 0                                 |
| ASW EQUIP              | 70             | 4                            | 46                                   | 1                               | 7                                 |
| YELLOW GEAR            | 1,787          | 90                           | 225                                  | 61                              | 152                               |
| PERISCOPES             | 361            | 18                           | 150                                  | 0                               | 2                                 |
| MISC EQUIP             | 1,706          | 86                           | 150                                  | 3                               | 5                                 |
| GRAND TOTALS           | 188,731        | 9,513                        | 29,268                               | 541                             | 1,968                             |

Potential Duplicate APL's and Parts

| Nomenclature       | 1988 Potential | 1988 Potential  | 1989 Potential | 1989 Potential  |
|--------------------|----------------|-----------------|----------------|-----------------|
|                    | APL Reduction  | Parts Reduction | APL Reduction  | Parts Reduction |
| PUMPS              | 24             | 103             | 24             | 103             |
| BOILERS            | 0              | 9               | 0              | 9               |
| HEAT EXCHANGERS    | 3              | 6               | 3              | 6               |
| CONDENSERS         | 1              | 1               | 1              | 1               |
| TURBINES           | 1              | 27              | 1              | 27              |
| COMPRESSORS        | 3              | 57              | 3              | 57              |
| HEATERS            | 9              | 11              | 9              | 11              |
| DISTILLING PLANTS  | 1              | 2               | 1              | 2               |
| BATTERY CHARGERS   | 1              | 5               | 1              | 5               |
| METERS             | 1              | 1               | 1              | 1               |
| CONVERTERS         | 2              | 12              | 2              | 12              |
| TRANSFORMERS       | 0              | 0               | 0              | 0               |
| CIRCUIT BREAKERS   | 8              | 19              | 8              | 19              |
| CONTROLLERS        | 49             | 195             | 56             | 226             |
| GENERATORS         | 3              | 14              | 6              | 24              |
| MOTORS             | 49             | 62              | 49             | 62              |
| MOTOR GENERATORS   | 0              | 1               | 0              | 1               |
| RELAYS             | 3              | 4               | 3              | 4               |
| RHEOSTATS          | 0              | 0               | 0              | 0               |
| SWITCHES           | 25             | 25              | 29             | 29              |
| SWITCHBOARDS       | 4              | 14              | 4              | 14              |
| VISUAL ALARMS      | 1              | 1               | 1              | 1               |
| LIGHTING FIXTURES  | 2              | 2               | 2              | 2               |
| GYRO COMPASSES     | 1              | 10              | 1              | 10              |
| PROJECTION EQUIP   | 0              | 2               | 0              | 2               |
| I/C EQUIP          | 2              | 9               | 2              | 9               |
| NAVIGATIONAL EQUIP | 2              | 24              | 3              | 29              |
| INJECTORS          | 0              | 1               | 0              | 1               |
| BURNERS            | 0              | 2               | 0              | 2               |
| MARINE HARDWARE    | 2              | 4               | 2              | 4               |
| REFRIG EQUIP       | 24             | 60              | 27             | 68              |
| AIR CONDITIONING   | 1              | 4               | 1              | 4               |
| STARTERS           | 1              | 5               | 1              | 5               |
| WIPERS             | 0              | 1               | 0              | 1               |
| AUDIBLE ALARMS     | 1              | 1               | 1              | 1               |
| BEARINGS           | 1              | 1               | 1              | 1               |
| INDICATORS         | 8              | 20              | 8              | 20              |
| CLUTCHES           | 0              | 2               | 0              | 2               |
| FANS               | 5              | 2               | 5              | 2               |
| SHOP EQUIP         | 10             | 20              | 15             | 30              |
| REGULATORS         | 1              | 5               | 1              | 5               |
| GALLEY EQUIP       | 10             | 33              | 10             | 33              |
| DEHYDRATORS        | 1              | 4               | 1              | 4               |
| GAGES              | 7              | 8               | 7              | 8               |
| TESTING EQUIP      | 3              | 14              | 3              | 14              |
| FILTERS            | 10             | 25              | 10             | 25              |
| PANELS             | 11             | 34              | 11             | 34              |

Potential Duplicate APL's and Parts

| Nomenclature           | 1988 Potential<br>APL Reduction | 1988 Potential<br>Parts Reduction | 1989 Potential<br>APL Reduction | 1989 Potential<br>Parts Reduction |
|------------------------|---------------------------------|-----------------------------------|---------------------------------|-----------------------------------|
| ISOLATORS              | 0                               | 0                                 | 0                               | 0                                 |
| HYDRALIC EQUIP         | 11                              | 64                                | 13                              | 77                                |
| CAPSTANS               | 0                               | 1                                 | 0                               | 2                                 |
| REELS                  | 2                               | 6                                 | 2                               | 7                                 |
| DAVITS                 | 0                               | 0                                 | 0                               | 0                                 |
| CRANES                 | 1                               | 5                                 | 1                               | 5                                 |
| HOISTS                 | 2                               | 8                                 | 2                               | 8                                 |
| ELEVATORS              | 1                               | 4                                 | 1                               | 4                                 |
| STEERING EQUIP         | 0                               | 4                                 | 0                               | 4                                 |
| CONTROL EQUIP          | 17                              | 56                                | 17                              | 56                                |
| WINCHES                | 3                               | 21                                | 4                               | 25                                |
| WINDLASSES             | 0                               | 2                                 | 0                               | 2                                 |
| FIREFIGHTING EQUIP     | 3                               | 14                                | 3                               | 14                                |
| LUBRICATORS            | 1                               | 2                                 | 1                               | 2                                 |
| ENGINES                | 2                               | 231                               | 2                               | 231                               |
| PLUMBING EQUIP         | 1                               | 1                                 | 1                               | 1                                 |
| GEARS AND REDUCERS     | 3                               | 18                                | 3                               | 18                                |
| GOVERNORS              | 3                               | 51                                | 3                               | 60                                |
| IGNITION EQUIP         | 0                               | 0                                 | 0                               | 0                                 |
| EJECTORS               | 0                               | 1                                 | 0                               | 1                                 |
| EDUCTORS               | 0                               | 0                                 | 0                               | 0                                 |
| STRAINERS              | 5                               | 4                                 | 5                               | 4                                 |
| PURIFIERS              | 1                               | 31                                | 1                               | 31                                |
| TRAPS-STEAM            | 1                               | 1                                 | 1                               | 1                                 |
| COUPLINGS              | 4                               | 4                                 | 5                               | 5                                 |
| SILENCING EQUIP        | 0                               | 0                                 | 0                               | 0                                 |
| BRAKES                 | 2                               | 3                                 | 2                               | 3                                 |
| BLOWERS                | 0                               | 6                                 | 0                               | 6                                 |
| WELDING SYSTEMS        | 2                               | 9                                 | 2                               | 9                                 |
| BOAT PROPULSION        | 1                               | 2                                 | 1                               | 2                                 |
| DECK MACHINERY         | 2                               | 7                                 | 2                               | 7                                 |
| PHOTOGRAPHIC EQUIP     | 0                               | 0                                 | 0                               | 0                                 |
| UNDERWATER LOG EQUIP   | 0                               | 1                                 | 0                               | 1                                 |
| VALVES                 | 99                              | 149                               | 99                              | 149                               |
| MISC PARTS             | 11                              | 183                               | 11                              | 183                               |
| LAUNDRY EQUIP          | 14                              | 97                                | 17                              | 116                               |
| TANKS                  | 1                               | 1                                 | 1                               | 1                                 |
| PIPE, HOSE, & FITTINGS | 0                               | 0                                 | 0                               | 0                                 |
| ASW EQUIP              | 1                               | 7                                 | 1                               | 7                                 |
| YELLOW GEAR            | 61                              | 152                               | 61                              | 152                               |
| PERISCOPES             | 0                               | 2                                 | 0                               | 2                                 |
| MISC EQUIP             | 3                               | 5                                 | 3                               | 5                                 |
| GRAND TOTALS           | 552                             | 2,017                             | 582                             | 2,132                             |



## APPENDIX D : NSLC MODEL

PTD. The cost of PTD, the first element of the model, "...refers only to the PTD development costs experienced by the contractor. Since these costs would be listed as 'Not Separately Priced' on the contract's supply schedule, they should be set equal to zero for the purposes of the government's life cycle cost formula."<sup>115</sup> Should the contractor bid based on government owned drawings, then by default the cost would be zero.

Provisioning. Costs for provisioning include "...PTD analysis, maintenance philosophies, and management data that go into establishing an APL."<sup>116</sup> Using the NAVSEA developed Level of Repair Analysis (LORA) model the formula is:

$$CP = 450 + 300(NPN) + 75(NP),$$

where CP is the Cost for provisioning;  
NPN is the number of new parts being added to the supply system,  
and;  
NP is the number of parts currently in the system.

Using the 25% factor for new parts discussed in Chapter III, the formula reduces to:

$$CP = 450 + 131.25(P),$$

where P is the number of different parts in the equipment.

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<sup>115</sup> LCDR Poe, Paper, p 7.

<sup>116</sup> LCDR Poe, Paper, p 7-8.

NSN. Increasing the NSN population results in additional management costs. A 1981 Army study found that it annually cost \$448 to manage each NSN. This cost was comprised of:

|                                       |                        |
|---------------------------------------|------------------------|
| "Supply Operations                    | \$ 34.10               |
| Requirements Computations             | 119.35                 |
| Logistics Data Management             | 85.25                  |
| Distribution and Transportation       | 102.30                 |
| DLSC Data Storage and Data Management | 107.00" <sup>117</sup> |

Using these costs, the formula for the additional management costs, CM, is:

$$CM = 448(NPN)(L),$$

where L is the projected life cycle of the equipment.

Training. The costs of training resulting from the introduction of a new piece of equipment include:

- (a) Length of training
- (b) Training equipment
- (c) Course material
- (d) Training site and maintenance costs
- (e) Travel and labor costs

The length of training is dependent on the equipment's complexity. If the equipment is being introduced as a replacement, then it is assumed that the costs for (a) have been established and the value is zero.

The formula assumes that the current practice of using a training facility on both coasts will continue. Furthermore, the model assumes the costs to maintain each site will average 50% of the original procurement cost of the equipment per year per site, and that training will stop four years prior to the end of the projected life.

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<sup>117</sup> U.S. Army DARCOM Catalog Data Activity Memorandum, Cost to Establish and Maintain an NSN, 19 November 1981.

The formula for the total additional training costs is therefore:

$$CT = 2(PR) + .5(2PR)(L-4),$$

where CT is the cost of additional training  
PR is the equipment unit price

The formula can be simplified to:

$$CT = PR(L-2).$$

Technical Manuals. The introduction of a new equipment or part requires changes to technical manuals. Using the LORA model as a basis, the cost for a manual is:

$$CTM = 62.5(P) + 20(Pop),$$

where CTM is the cost for technical manuals, and  
Pop is the number of ships.

If the equipment is being introduced as a replacement, then it is assumed that the distribution costs have been established and the value is zero. The formula then becomes:

$$CTM = 62.5(P).$$

Installation Drawings. The addition of a new piece of equipment requires the one-time charge for installation drawings. Assuming that there is only one drawing needed for each ship class, then the formula is:

$$CD = 1,000(CL),$$

where CD is the cost for installation drawings, and  
CL is the number of classes.

Configuration Control. The Consolidated Shipboard Allowance List (COSAL) is the single most important document used by the afloat supply officer to provide supply support while deployed. Maintenance of the COSAL through the OPNAV 4790/CK form by the NAVSEA system

prevents support degradation. This cost for processing the forms, as estimated by Ships Engineering Configuration Accounting System (SECAS) personnel, is \$20 each. The formula is:

$$CC = 20(Pop),$$

where CC is the cost of configuration control.

This cost only covers computer related processing. It does not include the cost for the sailor to complete the form or for the system to make changes reflecting the new configuration.

Testing. A basic premise of the model is that the procurement is based on a performance specification. When an item is purchased on this basis, then first article testing is already included as one of the acquisition costs. If the equipment has been previously tested, then it is the government's prerogative whether to pay for further testing. In light of this argument, no testing costs are required.

Planned Maintenance. "Although Planned Maintenance (PMS) is an integral part of ILS, consideration in the economic analysis related to competitive procurement is minimal. The logic for this hypothesis is that if PMS is necessary to support the originally installed equipment, then the similarity between the competed equipment and the original equipment would necessitate similar PMS. The only significant difference would be in the identification of required repair parts on the individual Maintenance Requirement Cards (MRC), a review of the original Mrc's to assure compatibility with the competed equipment and promulgation of the new

MRC's. The average value for this non-recurring effort is estimated at \$500.00."<sup>118</sup>

Total Costs. The formula for computing the total hidden ILS costs, C, that result from the introduction of new equipment is therefore:

$$C = 450 + 131.25(P) + 448(NPN)(L) + PR(L-2) + 62.5(P) + 1000(CL) + 20(Pop) + 500$$

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<sup>118</sup> Mr. Richard Jones, H,M&E Standardization.

## APPENDIX E : DESC MODEL<sup>119</sup>

Non-Standard Documentation. A National Aerospace Standards Committee (NASC) survey noted that it took an engineer between 2 and 145 hours to develop a drawing for a new part and that 67% of all drawings were for new parts. He then estimated that drawings per part for a stud averaged 27 manhours. (Other averages are provided, but this was the only pertinent H,M&E example.) Using a 1973 industry average of \$25 per manhour and a conservative 50% rather than 67% for new part drawings, the cost formula for nonstandard documentation is:

$$\text{DOC} = (\text{MH})(\$/\text{MH})(\%\text{ND}),$$

where MH is the number of manhours,  
\$/MH is the cost per MH, and  
%ND is the percentage of new drawings.

Substitution of the average costs above in this formula results in a drawing avoidance benefit of \$337.50.

Testing. The formula for testing is:

$$\text{TEST} = (\%\text{PT})(\$/\text{T}),$$

where TEST is the total cost for testing,  
%PT is the percentage of parts tested, and  
\$/T is the average cost per test.

An NASC study indicated that 70% of all electronic parts are tested and MPCAG estimated that average cost for testing a mechanical part was

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<sup>119</sup> Messrs. Charles E. Gastineau and Donald L. Kerr, "Don't Cry: Justify", from The Economics of Standardization, edited by Robert B. Toth, p 63. Unless otherwise noted, information for this discussion is taken from Messrs. Gastineau's and Kerr's article.

\$4,800. Again being conservative and using 25% (as opposed to 70%), the average cost to test is \$1,200 per part.

NSN Management. The formula for NSN management, which includes both one-time charges and annual inventory maintenance costs, is:

$$IM = [(\$ / C) + (y)(M\$ / y)](\%ND)(NPN),$$

where IM is the total inventory management costs over y years,  
\$ / C is the cost to catalog (a one-time charge),  
y is the number of years (10 years in the model),  
M\$ / y is the management cost per year, and  
NPN is the number of new parts per drawing.

The NASC survey found that the average drawing contained 7.3 parts, but that only 3 were provisioned. (The article did not indicate whether the remaining 4.3 parts were already in the system or if the government intentionally decided against stocking them.) The survey also noted that a part had a life expectancy of 10 years before it was upgraded. Mr. Gastineau estimated that it cost \$207 to enter a part into the system and a 1968 DLA report stated that it cost \$165 per year to manage it. Assuming that the use of a standard prevented preparation of a drawing 50% of the time and thus excluded 3 new parts 50% of the time, inventory management costs are \$2,785.50 per part.

Maintenance. The annual formula for depot maintenance is:

$$MC = (y)(\$R / y),$$

where MC is maintenance costs, and  
\$R / y is the annual repair costs.

The model uses a standard \$300 per year for maintenance costs for Electronics, but \$0 for H,M&E since it is not returned to a depot for repair. (This may not be a realistic assumption).

Total Costs. Combining the above elements results in the following per part total life cycle cost avoidance formula per part:

$$CA = (MH)(\$/MH)(\%ND) + (\%PT)(\$/T) + [(\$/C) + (y)(M\$/y)](\%ND)(NPN) + (y)(\$/R/y).$$

Its value for the example is:

$$CA = \$4,323.00.$$



## APPENDIX F : AIAA MODEL<sup>120</sup>

Increased Quantity Purchases. The savings attainable through increased quantity purchases is:

$$Sqb = Qn(Cn) - Qn(Cs),$$

where Sqb is the cost reduction resulting from volume purchases,  
Qn is the number of parts purchased yearly if not replaced by a standard part,  
Cn is the actual cost of the part, and  
Cs is the price of the standard part based on the volume change.

Reduced Paperwork and Handling. The formula for savings attained through the reduction of paperwork is:

$$Spw = (N_1 - N_2)(K) + (D_1 - D_2)(J + M),$$

where Spw is the cost avoided through paperwork reduction,  
N<sub>1</sub> is the number of orders before standardization,  
N<sub>2</sub> is the number of orders after standardization,  
K is the cost to process each order,  
D<sub>1</sub> is the number of shipments received before standardization,  
D<sub>2</sub> is the number of shipments received after standardization,  
J is the cost of paperwork for storage processing, and  
M is the receiving cost inspection.

Reduced Storage Requirements. The formula for savings achieved through reduced storage requirements is:

$$Ssp = (Ccf)(V_1 - V_2),$$

where Ssp is the savings accrued from reduced warehousing requirements,  
Ccf is the annual cost to maintain one cubic foot of warehouse,  
V<sub>1</sub> is the number of feet occupied before standardization, and  
V<sub>2</sub> is the number of feet occupied after standardization.

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<sup>120</sup> This entire section is taken from the National Aerospace Standard 1524 of the Aerospace Industries of America, Chapter 5 of The Economics of Standardization, pp 94-106.

Reduced Engineering Search Time. The savings realized through the use of standard manuals is computed as:

$$\text{Sys} = (N)(\text{Re})[(\text{Tef})(\text{Rs}) - (\text{Tsm})] - \text{Cos},$$

where Sys is the savings avoided resulting from reduced search time,  
 N is the average number of searches,  
 Re is the burdened engineering rate per hour,  
 Tef is the time to perform each search using engineering files,  
 Rs is the search success rate using standard documents,  
 Tsm is the time to search in standard documents, and  
 Cos is the annual cost to publish and maintain standard documents.

Standard Stock vice Establishing a New Standard. The savings realized by using a standard part rather than preparing a new standard is computed as:

$$S_1 = (Q)(C_1 - C_2) + \text{Ces} + (I)[(Q/2)(C_1 - C_2)] + Y,$$

$$S_d = (Q)(C_1 - C_2) + (I)[(Q/2)(C_1 - C_2)] + Y,$$

where  $S_1$  is the savings the first year,  
 $S_d$  is the savings during succeeding years,  
 Q is the annual quantity purchased  
 $C_1$  is the unit cost of the new standard part,  
 $C_2$  is the unit cost of the new part if increased quantities are purchased,  
 Ces is the cost of establishing a new standard part,  
 I is the carrying cost, and  
 Y any additional savings, including intangibles that might be achieved.

Standard Stock vice New Design. The engineering savings realized by using a standard part rather than a new part is computed as:

$$S_1 = (Q)(C_1 - C_2) + \text{Crs} + \text{Cqt} + (I)[(Q/2)(C_1 - C_2)] + (\text{He})(\text{Re}) + (\text{Hd})(\text{Rd}) + Y,$$

$$S_d = (Q)(C_1 - C_2) + (I)[(Q/2)(C_1 - C_2)] + Y,$$

where Crs is the cost of issuing a part,  
 Cqt is the cost of qualification testing,  
 He is the estimated number of hours to engineer the new part,  
 Re is the standard, including overhead, engineering rate,  
 Hd is the estimated number of hours to design the part, and  
 Rd is the standard, including overhead, design hours.

Reduction of Inventory Range. The formula for computing savings resulting from inventory consolidation ( $S_{ri}$ ) is:

$$S_{ri} = [C_{mi} - C_{imp}](N),$$

where  $C_{mi}$  is the annual cost for stocking and issuing a part,  
 $C_{imp}$  is the cost to implement a standardization program on a per item basis, and  
 $N$  is the number of parts eliminated.

Stocked Standard Part vice Nonstocked Part. The savings achieved by using stocked standard parts in lieu of nonstocked, nonstandard parts ( $S_{np}$ ) is computed as:

$$S_{np} = (C_{es} - C_{imp})(N).$$

Design Standards. The formula for computing savings achievable by using a design standard in lieu of detailing ( $S_{ds}$ ) the complete design is:

$$S_{ds} = (R_d)[(N)(H_{d_1} - H_{d_2}) - (H_{es})] + Y,$$

where  $H_{d_1}$  is the number of hours to detail the design element on an engineering drawing,  
 $H_{d_2}$  is the number of hours to specify a design standard on an engineering drawing, and  
 $H_{es}$  is the additional savings that might be applicable.

## **APPENDIX G : NSLC AND DESC MODEL RESULTS**

Appendix G provides the comparative results of the NSLC and DESC cost models discussed in Chapter IV, and described in Appendices D and E, and is presented in two parts. The first presents the NSLC model costs for 1987 through 1989 and the DESC model costs for 1987 and 1988. The second part presents the DESC model costs for 1989.

## Standardization Costs Using NSLC and DESC Models

| Nomenclature       | 1987 Cost<br>NSLC Model | 1988 Cost<br>NSLC Model | 1989 Cost<br>NSLC Model | 1987 Cost<br>DESC Model | 1988 Cost<br>DESC Model |
|--------------------|-------------------------|-------------------------|-------------------------|-------------------------|-------------------------|
| PUMPS              | 14,229,189              | 14,940,648              | 15,687,680              | 11,154,274              | 11,711,988              |
| BOILERS            | 1,482,314               | 1,556,430               | 1,634,251               | 1,030,089               | 1,081,593               |
| HEAT EXCHANGERS    | 860,866                 | 903,910                 | 949,105                 | 624,628                 | 655,860                 |
| CONDENSERS         | 256,973                 | 269,822                 | 283,313                 | 135,610                 | 142,391                 |
| TURBINES           | 4,937,001               | 5,183,851               | 5,443,043               | 2,940,959               | 3,088,007               |
| COMPRESSORS        | 8,068,940               | 8,472,387               | 8,896,006               | 6,222,997               | 6,534,147               |
| HEATERS            | 1,505,938               | 1,581,235               | 1,660,297               | 1,178,027               | 1,236,929               |
| DISTILLING PLANTS  | 458,133                 | 481,039                 | 505,091                 | 241,085                 | 253,139                 |
| BATTERY CHANGERS   | 586,115                 | 720,420                 | 756,441                 | 513,675                 | 539,358                 |
| METERS             | 137,791                 | 144,680                 | 151,914                 | 86,297                  | 90,612                  |
| CONVERTERS         | 1,680,253               | 1,764,265               | 1,852,479               | 1,260,215               | 1,323,226               |
| TRANSFORMERS       | 21,892                  | 22,987                  | 24,136                  | 12,328                  | 12,945                  |
| CIRCUIT BREAKERS   | 2,609,793               | 2,740,282               | 2,877,297               | 2,054,699               | 2,157,434               |
| CONTROLLERS        | 24,509,528              | 28,240,289              | 34,306,350              | 19,329,023              | 22,271,312              |
| GENERATORS         | 2,934,962               | 2,803,156               | 4,524,331               | 1,735,775               | 1,602,821               |
| MOTORS             | 8,552,973               | 8,980,621               | 9,429,652               | 6,718,865               | 7,054,808               |
| MOTOR GENERATORS   | 436,684                 | 458,519                 | 481,445                 | 147,938                 | 155,335                 |
| RELAYS             | 508,122                 | 533,520                 | 560,205                 | 397,242                 | 417,104                 |
| RHEOSTATS          | 60,973                  | 64,021                  | 67,223                  | 41,094                  | 43,149                  |
| SWITCHES           | 3,168,458               | 3,618,596               | 4,341,442               | 2,494,438               | 2,849,284               |
| SWITCHBOARDS       | 1,974,051               | 2,072,753               | 2,176,391               | 1,499,930               | 1,574,927               |
| VISUAL ALARMS      | 194,779                 | 204,518                 | 214,744                 | 147,938                 | 155,335                 |
| LIGHTING FIXTURES  | 333,528                 | 350,205                 | 367,715                 | 260,262                 | 273,275                 |
| GYRO COMPASSES     | 1,379,177               | 1,448,135               | 1,520,542               | 1,041,047               | 1,093,100               |
| PROJECTION EQUIP   | 269,999                 | 283,394                 | 297,564                 | 210,949                 | 221,497                 |
| I/C EQUIP          | 1,304,110               | 1,369,316               | 1,437,782               | 1,008,172               | 1,058,581               |
| NAVIGATIONAL EQUIP | 2,963,583               | 3,500,100               | 4,396,540               | 2,332,673               | 2,755,660               |
| INJECTORS          | 153,024                 | 160,675                 | 168,709                 | 106,844                 | 112,187                 |
| BURNERS            | 454,703                 | 477,438                 | 501,310                 | 246,564                 | 258,892                 |
| MARINE HARDWARE    | 571,514                 | 600,090                 | 630,094                 | 438,336                 | 460,252                 |
| REFRIG EQUIP       | 7,711,311               | 8,775,703               | 10,475,537              | 6,008,158               | 6,844,070               |
| AIR CONDITIONING   | 622,869                 | 654,012                 | 686,713                 | 462,992                 | 486,142                 |
| STARTERS           | 808,546                 | 848,974                 | 891,422                 | 575,316                 | 604,081                 |
| WIPERS             | 148,944                 | 156,391                 | 164,210                 | 115,063                 | 120,816                 |
| AUDIBLE ALARMS     | 233,087                 | 244,741                 | 256,978                 | 136,980                 | 143,829                 |
| BEARINGS           | 266,070                 | 279,374                 | 293,342                 | 95,886                  | 100,680                 |
| INDICATORS         | 2,810,931               | 2,951,477               | 3,099,051               | 2,205,377               | 2,315,645               |
| CLUTCHES           | 553,743                 | 581,430                 | 610,501                 | 208,209                 | 218,620                 |
| FANS               | 345,222                 | 362,483                 | 380,608                 | 252,043                 | 264,545                 |
| SHOP EQUIP         | 3,020,896               | 2,850,673               | 4,567,481               | 2,371,572               | 2,236,712               |
| REGULATORS         | 732,734                 | 769,370                 | 807,839                 | 567,097                 | 595,452                 |
| GALLEY EQUIP       | 4,647,514               | 4,879,890               | 5,123,884               | 3,614,900               | 3,795,645               |
| DEHYDRATORS        | 659,115                 | 692,070                 | 726,674                 | 391,763                 | 411,351                 |
| GAGES              | 1,143,830               | 1,201,021               | 1,261,072               | 890,369                 | 934,888                 |
| TESTING EQUIP      | 1,913,703               | 2,009,388               | 2,109,858               | 1,490,341               | 1,564,858               |
| FILTERS            | 3,459,091               | 3,632,046               | 3,813,648               | 2,712,202               | 2,847,812               |
| PANELS             | 4,688,519               | 4,922,945               | 5,169,092               | 3,682,020               | 3,866,121               |

Standardization Costs Using NSLC and DESC Models

| Nomenclature           | 1987 Cost<br>NSLC Model | 1988 Cost<br>NSLC Model | 1989 Cost<br>NSLC Model | 1987 Cost<br>DESC Model | 1988 Cost<br>DESC Model |
|------------------------|-------------------------|-------------------------|-------------------------|-------------------------|-------------------------|
| ISOLATORS              | 49,517                  | 51,993                  | 54,593                  | 0                       | 0                       |
| HYDRALIC EQUIP         | 8,182,517               | 9,637,012               | 12,060,641              | 6,209,729               | 7,344,790               |
| CAPSTANS               | 418,422                 | 429,820                 | 525,435                 | 119,187                 | 117,634                 |
| REELS                  | 752,929                 | 865,872                 | 1,049,044               | 574,583                 | 662,711                 |
| DAVITS                 | 187,880                 | 197,274                 | 207,138                 | 38,354                  | 40,272                  |
| CRANES                 | 1,482,815               | 1,556,956               | 1,634,804               | 542,440                 | 569,562                 |
| HOISTS                 | 1,182,644               | 1,241,776               | 1,303,864               | 910,916                 | 956,462                 |
| ELEVATORS              | 605,611                 | 635,891                 | 667,686                 | 427,377                 | 448,746                 |
| STEERING EQUIP         | 497,369                 | 522,238                 | 548,349                 | 390,393                 | 409,912                 |
| CONTROL EQUIP          | 7,664,309               | 8,047,524               | 8,449,900               | 6,036,705               | 6,338,540               |
| WINCHES                | 2,894,692               | 3,346,629               | 4,084,647               | 2,067,313               | 2,413,020               |
| WINDLASSES             | 445,856                 | 468,149                 | 491,556                 | 191,772                 | 201,360                 |
| FIREFIGHTING EQUIP     | 2,007,877               | 2,108,270               | 2,213,684               | 1,561,571               | 1,639,650               |
| LUBRICATORS            | 256,383                 | 269,202                 | 282,662                 | 191,772                 | 201,360                 |
| ENGINES                | 32,411,991              | 34,032,591              | 35,734,221              | 25,083,761              | 26,337,949              |
| PLUMBING EQUIP         | 158,769                 | 166,707                 | 175,043                 | 123,282                 | 129,446                 |
| GEARS AND REDUCERS     | 2,887,031               | 3,031,382               | 3,182,952               | 1,986,209               | 2,085,519               |
| GOVERNORS              | 6,379,558               | 7,473,522               | 9,286,882               | 4,350,002               | 5,008,863               |
| IGNITION EQUIP         | 30,497                  | 32,022                  | 33,623                  | 0                       | 0                       |
| EJECTORS               | 226,589                 | 237,918                 | 249,814                 | 102,735                 | 107,872                 |
| EDUCTORS               | 49,398                  | 55,041                  | 63,690                  | 16,414                  | 19,738                  |
| STRAINERS              | 560,774                 | 588,813                 | 618,254                 | 439,706                 | 461,691                 |
| PURIFIERS              | 4,422,073               | 4,643,176               | 4,875,335               | 3,347,789               | 3,515,178               |
| TRAPS-STEAM            | 102,784                 | 107,923                 | 113,320                 | 76,709                  | 80,544                  |
| COUPLINGS              | 686,391                 | 783,655                 | 939,770                 | 427,709                 | 498,749                 |
| SILENCING EQUIP        | 45,588                  | 47,868                  | 50,261                  | 28,766                  | 30,204                  |
| BRAKES                 | 446,462                 | 468,785                 | 492,224                 | 336,971                 | 353,819                 |
| BLOWERS                | 846,635                 | 888,967                 | 933,415                 | 604,081                 | 634,285                 |
| WELDING SYSTEMS        | 1,256,181               | 1,318,990               | 1,384,939               | 988,995                 | 1,038,445               |
| BOAT PROPULSION        | 712,382                 | 748,001                 | 785,401                 | 249,303                 | 261,769                 |
| DECK MACHINERY         | 953,546                 | 1,001,223               | 1,051,284               | 723,254                 | 759,417                 |
| PHOTOGRAPHIC EQUIP     | 65,003                  | 68,253                  | 71,565                  | 49,313                  | 51,778                  |
| UNDERWATER LOG EQUIP   | 166,664                 | 174,997                 | 183,747                 | 82,188                  | 86,297                  |
| VALVES                 | 20,507,789              | 21,533,178              | 22,609,837              | 16,174,588              | 16,983,317              |
| MISC PARTS             | 25,238,899              | 26,500,844              | 27,825,886              | 19,900,441              | 20,895,463              |
| LAUNDRY EQUIP          | 11,877,300              | 14,034,010              | 17,638,994              | 9,325,410               | 11,024,558              |
| TANKS                  | 567,142                 | 595,499                 | 625,274                 | 157,527                 | 165,403                 |
| PIPE, HOSE, & FITTINGS | 87,432                  | 91,804                  | 96,394                  | 21,917                  | 23,013                  |
| ASW EQUIP              | 1,009,813               | 1,060,304               | 1,113,319               | 712,296                 | 747,910                 |
| YELLOW GEAR            | 20,960,978              | 22,009,027              | 23,109,478              | 16,533,475              | 17,360,149              |
| PERISCOPES             | 421,779                 | 442,868                 | 465,012                 | 271,220                 | 284,781                 |
| MISC EQUIP             | 649,112                 | 681,568                 | 715,646                 | 508,195                 | 533,605                 |
| GRAND TOTALS           | 280,828,871             | 301,956,850             | 334,580,690             | 213,876,627             | 230,160,797             |

## Standardization Costs Using NSLC and DESC Models

| Nomenclature       | 1989 Cost<br>DESC Model |
|--------------------|-------------------------|
| PUMPS              | 12,297,587              |
| BOILERS            | 1,135,673               |
| HEAT EXCHANGERS    | 688,653                 |
| CONDENSERS         | 149,510                 |
| TURBINES           | 3,242,407               |
| COMPRESSORS        | 6,860,855               |
| HEATERS            | 1,298,775               |
| DISTILLING PLANTS  | 265,796                 |
| BATTERY CHANGERS   | 566,326                 |
| METERS             | 95,143                  |
| CONVERTERS         | 1,389,387               |
| TRANSFORMERS       | 13,592                  |
| CIRCUIT BREAKERS   | 2,265,305               |
| CONTROLLERS        | 27,056,830              |
| GENERATORS         | 2,930,176               |
| MOTORS             | 7,407,548               |
| MOTOR GENERATORS   | 163,102                 |
| RELAYS             | 437,959                 |
| RHEOSTATS          | 45,306                  |
| SWITCHES           | 3,419,249               |
| SWITCHBOARDS       | 1,653,673               |
| VISUAL ALARMS      | 163,102                 |
| LIGHTING FIXTURES  | 286,939                 |
| GYRO COMPASSES     | 1,147,755               |
| PROJECTION EQUIP   | 232,571                 |
| I/C EQUIP          | 1,111,510               |
| NAVIGATIONAL EQUIP | 3,462,553               |
| INJECTORS          | 117,796                 |
| BURNERS            | 271,837                 |
| MARINE HARDWARE    | 483,265                 |
| REFRIG EQUIP       | 8,181,074               |
| AIR CONDITIONING   | 510,449                 |
| STARTERS           | 634,285                 |
| WIPERS             | 126,857                 |
| AUDIBLE ALARMS     | 151,020                 |
| BEARINGS           | 105,714                 |
| INDICATORS         | 2,431,428               |
| CLUTCHES           | 229,551                 |
| FANS               | 277,877                 |
| SHOP EQUIP         | 3,590,442               |
| REGULATORS         | 625,224                 |
| GALLEY EQUIP       | 3,985,427               |
| DEHYDRATORS        | 431,918                 |
| GAGES              | 981,632                 |
| TESTING EQUIP      | 1,643,101               |
| FILTERS            | 2,990,203               |
| PANELS             | 4,059,427               |

## Standardization Costs Using NSLC and DESC Models

| Nomenclature           | 1989 Cost<br>DESC Model |
|------------------------|-------------------------|
| ISOLATORS              | 0                       |
| HYDRALIC EQUIP         | 9,243,836               |
| CAPSTANS               | 181,990                 |
| REELS                  | 806,192                 |
| DAVITS                 | 42,286                  |
| CRANES                 | 598,041                 |
| HOISTS                 | 1,004,285               |
| ELEVATORS              | 471,183                 |
| STEERING EQUIP         | 430,408                 |
| CONTROL EQUIP          | 5,655,467               |
| WINCHES                | 2,983,868               |
| WINDLASSES             | 211,428                 |
| FIREFIGHTING EQUIP     | 1,721,632               |
| LUBRICATORS            | 211,428                 |
| ENGINES                | 27,654,347              |
| PLUMBING EQUIP         | 135,318                 |
| GEARS AND REDUCERS     | 2,189,795               |
| GOVERNORS              | 7,235,127               |
| IGNITION EQUIP         | 0                       |
| EJECTORS               | 113,265                 |
| EDUCTORS               | 25,376                  |
| STRAINERS              | 484,775                 |
| PURIFIERS              | 3,690,937               |
| TRAPS-STEAM            | 84,571                  |
| COUPLINGS              | 615,931                 |
| SILENCING EQUIP        | 31,714                  |
| BRAKES                 | 371,510                 |
| BLOWERS                | 666,000                 |
| WELDING SYSTEMS        | 1,090,367               |
| BOAT PROPULSION        | 274,857                 |
| DECK MACHINERY         | 797,387                 |
| PHOTOGRAPHIC EQUIP     | 54,367                  |
| UNDERWATER LOG EQUIP   | 30,612                  |
| VALVES                 | 17,832,483              |
| MISC PARTS             | 21,940,237              |
| LAUNDRY EQUIP          | 13,866,094              |
| TANKS                  | 173,673                 |
| PIPE, HOSE, & FITTINGS | 24,163                  |
| ASW EQUIP              | 785,306                 |
| YELLOW GEAR            | 10,328,155              |
| PERISCOPES             | 299,020                 |
| MISC EQUIP             | 560,286                 |
| GRAND TOTALS           | 255,494,533             |



## APPENDIX H : STANDARDIZATION COSTING MODEL<sup>121</sup>

As noted in Chapter IV, the model combines the elements from both the NSLC and DESC models. In many cases, the formulas are repeated so the reader does not have to keep referring to previous appendices. Justification for element selection will only be provided where the formulas deviate from their predecessors.

### 1. NON-RECURRING COSTS

Non-Standard Technical Data. Technical data must be purchased when a new equipment is introduced if the supply system is to ensure proper support. As discussed in Chapter IV, the NSLC Data Ownership Model for estimating technical data required too many broad assumptions to be valid. Using a Best Replacement Factor (BRF) of 10%, a system life of 10 years, and not compensating for testing costs, the NSLC model estimated a technical data cost of \$9.549M per new pump per year. This value was intuitively too high to be acceptable. However, the costs are required if the model is to be valid. The next alternative was the non-standard documentation costs provided in the DESC model.

The AIAA survey found that each drawing contained an average of 7.3 parts, and that 67% of the parts were new to the supply system. This equated to 4.89 parts per drawing. For conservative purposes, a median

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<sup>121</sup> All constants used in the actual calculation were inflated at an annual rate of 5%. However, in this appendix the values used in the NSLC and DESC models are presented to prevent confusion in understanding the derivation of the model.

of 4 nonstandard parts/drawing was used in the model. Additionally, the number of drawings needed were rounded to the nearest complete drawing. Thus the cost formula for drawings is:

$$\text{DOC} = (\text{MH})(\$/\text{MH})[(\text{NSP})/4](\text{E}),$$

where NSP is the number of Non-Standard Parts, and  
E is the number of new equipment.

In 1982 DESC updated the cost per MH (\$/MH) to \$52/hour. Otherwise the 27 hours per drawing (M/H) remains consistent with the previous explanation. This formula was obtained from the DESC Model.

Provisioning. For ease in writing the equation in the software, this formula was left in its original state.

$$\text{CP} = 450 + \{[300(\text{NSP}) + 75(\text{SP})](\text{E})\},$$

where SP is the number of Standardized Parts per each new equipment. This formula was obtained from the NSLC Model.

Testing. With the increasing attention to quality control, the percentage tested (%PT) was increased from DESC's estimate of 25 to 50%. Additionally, in 1982 DESC increased the cost per test to \$7,872 (\$/T).

$$\text{TEST} = (\%PT)(\$/T)(\text{NSP})(\text{E}).$$

Technical Manuals. The NSLC model assumes that the technical manual distribution costs have already been established. However, when an equipment is introduced, the manuals must still be sent to the fleet, so the cost for distribution is included in the algorithm. The formula for the cost of technical manuals (CTM) is:

$$\text{CTM} = 62.5(\text{P}) + 20(\text{Pop}),$$

where P is the number parts in the equipment, and  
Pop is the number of ships where the equipment is installed.

This formula was obtained from the NSLC Model.

#### Installation Drawings

$$CD = 1,000(CL).$$

CD is the cost of drawings, and  
CL is the number of classes of ships where the equipment is installed.

This formula was obtained from the NSLC Model.

Training Equipment. There are two costs for training, one for establishing the program and the other for annual operating expenses. This element considers the non-recurring costs for starting the program.

$$CT = 2(PR).$$

CT is the cost of training equipment, and  
PR is the equipment unit price.

#### Planned Maintenance

$$CPM = \$500.$$

CPM is the cost for planned maintenance.

This formula was obtained from the NSLC Model.

## 2. ANNUAL OPERATING COSTS

The operating costs are based on a 10-year life-cycle. The present value is computed using a 10% discount factor. Initially, the model was run using a 5% inflation factor for year 1. It was not factored in the annual costs for years 2 through 10. A second calculation was run computing the Net Present Value (NPV) assuming a 5% annual inflation rate.

### NSN Management Costs

$$CM = 448(NSP)(E).$$

This formula was obtained from the NSLC Model.

Training. Unlike the NSLC model, it is assumed that training on the equipment continues until the equipment is replaced.

$$CT = PR.$$

This formula was derived from the NSLC Model.

Configuration Control. Configuration control is an ongoing effort. It does not stop once the equipment is deployed. However, only parts that fail more than anticipated receive any attention.<sup>122</sup> The NSLC model is modified to reflect the failure rates of the parts. An arbitrary value of 10% was selected for the BRF. But the NSLC model only considers the cost to process OPNAV 4790/CK Forms. It does not include the time for a sailor to complete the form, an engineer to revise the part, and the configuration control board to meet and approve the change. Therefore, the \$20 per effort remains to compensate for the shortcomings, despite the change in the formula logic.

$$CC = 20(BRF)(NSP)(E).$$

This formula was obtained from the NSLC Model.

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<sup>122</sup> This assumes that the equipment is not constantly upgraded, and therefore the parts baseline remains stable.

Summarizing the formulas, the model for non-recurring costs is:

$$\begin{aligned} & \{ (MH)(\$/MH)[(NSP)/4](E) \} + \\ & \{ 450 + \{ [300(NSP) + 75(SP)](E) \} \} + \{ (\%PT)(\$/T)(NSP)(E) \} + \\ & \{ 62.5P + 20(Pop) \} + \{ 1,000(CL) \} + \{ 2PR \} + \{ 500 \}, \end{aligned}$$

and the model for annual costs is:

$$\{ 448(NSP)(E) \} + \{ PR \} + \{ 20(BRF)(NSP)(E) \}.$$

## **APPENDIX I : STANDARDIZATION COSTING MODEL RESULTS**

Appendix I provides the results of the Standardization Costing Model, I.1, and Duplication Reduction Savings, I.2, discussed in Chapter IV and described in Appendix H. In I.1 costs for each year are segregated in three columns. The first column for each year is the sum of the non-recurring costs and the present value, for ten years at 10%, of the annual costs for non-standardization. The second column lists the values of the non-recurring costs included in the first column. These are the "one-time" charges incurred when a new piece of equipment is introduced to the fleet. The third column provides the annual costs resulting from non-standardization. Only the annual cost for a single year is shown.

I.2 provides the results of the Standardization Costing Model when applied to reduction of duplicate parts.

I.1 1987 - 1989 Summary Estimated Costs for Non-Standardization (Uninflated)

| Nomenclature       | Total 1987<br>Est Costs | 1987 Non-<br>Recurring Costs | 1987 Annual<br>Costs | Total 1988<br>Est Costs | 1988 Non-<br>Recurring Costs |
|--------------------|-------------------------|------------------------------|----------------------|-------------------------|------------------------------|
| PUMPS              | 20,633,902              | 13,026,775                   | 1,238,025            | 21,665,597              | 13,678,113                   |
| BOILERS            | 2,083,530               | 1,253,520                    | 135,080              | 2,187,707               | 1,316,196                    |
| HEAT EXCHANGERS    | 1,302,938               | 829,562                      | 77,040               | 1,374,883               | 877,838                      |
| CONDENSERS         | 351,036                 | 195,939                      | 25,241               | 369,899                 | 207,048                      |
| TURBINES           | 6,659,083               | 3,744,384                    | 474,354              | 6,992,037               | 3,931,604                    |
| COMPRESSORS        | 11,694,234              | 7,350,858                    | 706,864              | 12,278,946              | 7,718,401                    |
| HEATERS            | 2,485,102               | 1,680,980                    | 130,867              | 2,629,872               | 1,785,543                    |
| DISTILLING PLANTS  | 600,398                 | 322,191                      | 45,277               | 630,418                 | 338,301                      |
| BATTERY CHARGERS   | 999,228                 | 627,048                      | 60,570               | 1,052,171               | 561,383                      |
| METERS             | 229,186                 | 150,953                      | 12,732               | 243,150                 | 161,005                      |
| CONVERTERS         | 2,379,835               | 1,466,289                    | 148,675              | 2,498,827               | 1,539,604                    |
| TRANSFORMERS       | 48,673                  | 37,441                       | 1,828                | 52,100                  | 40,387                       |
| CIRCUIT BREAKERS   | 3,974,302               | 2,583,275                    | 226,383              | 4,190,907               | 2,730,329                    |
| CONTROLLERS        | 35,698,449              | 22,528,444                   | 2,127,083            | 41,132,682              | 26,073,183                   |
| GENERATORS         | 3,344,619               | 2,208,914                    | 282,478              | 3,737,151               | 2,053,206                    |
| MOTORS             | 14,137,183              | 9,569,626                    | 743,349              | 14,961,045              | 10,155,110                   |
| MOTOR GENERATORS   | 535,266                 | 245,808                      | 47,108               | 563,103                 | 259,172                      |
| RELAYS             | 838,281                 | 568,157                      | 43,961               | 887,113                 | 503,483                      |
| RHEOSTATS          | 95,239                  | 62,553                       | 5,320                | 100,716                 | 66,396                       |
| SWITCHES           | 5,449,735               | 3,760,499                    | 274,915              | 6,283,458               | 4,354,137                    |
| SWITCHBOARDS       | 2,887,896               | 1,820,042                    | 173,788              | 3,040,998               | 1,919,751                    |
| VISUAL ALARMS      | 309,573                 | 205,916                      | 16,870               | 327,199                 | 218,358                      |
| LIGHTING FIXTURES  | 549,835                 | 373,040                      | 28,772               | 581,059                 | 396,225                      |
| GYRO COMPASSES     | 1,969,390               | 1,221,858                    | 121,657              | 2,067,860               | 1,282,951                    |
| PROJECTION EQUIP   | 392,681                 | 250,081                      | 23,208               | 412,316                 | 262,585                      |
| I/C EQUIP          | 1,888,130               | 1,188,469                    | 113,867              | 1,982,536               | 1,247,892                    |
| NAVIGATIONAL EQUIP | 4,326,667               | 2,746,641                    | 257,142              | 5,110,352               | 3,244,232                    |
| INJECTORS          | 217,160                 | 133,343                      | 13,641               | 228,018                 | 140,010                      |
| BURNERS            | 597,713                 | 323,771                      | 44,583               | 627,599                 | 339,959                      |
| MARINE HARDWARE    | 881,137                 | 574,555                      | 49,895               | 929,965                 | 608,054                      |
| REFRIG EQUIP       | 11,702,814              | 7,570,176                    | 672,568              | 13,379,145              | 8,677,878                    |
| AIR CONDITIONING   | 913,093                 | 574,405                      | 55,120               | 961,849                 | 606,227                      |
| STARTERS           | 1,146,098               | 698,229                      | 72,889               | 1,203,402               | 733,140                      |
| WIPERS             | 219,875                 | 141,637                      | 12,733               | 231,584                 | 149,435                      |
| AUDIBLE ALARMS     | 325,080                 | 188,738                      | 22,189               | 342,527                 | 199,367                      |
| BEARINGS           | 348,321                 | 174,414                      | 28,303               | 367,407                 | 184,805                      |
| INDICATORS         | 4,275,683               | 2,775,017                    | 244,227              | 4,500,670               | 2,932,970                    |
| CLUTCHES           | 676,772                 | 315,344                      | 58,821               | 710,610                 | 331,111                      |
| FANS               | 681,346                 | 493,124                      | 30,632               | 726,386                 | 528,752                      |
| SHOP EQUIP         | 4,694,994               | 3,082,525                    | 262,422              | 4,452,781               | 2,931,012                    |
| REGULATORS         | 1,056,058               | 663,973                      | 63,810               | 1,108,861               | 597,171                      |
| GALLEY EQUIP       | 6,909,903               | 4,418,144                    | 405,522              | 7,279,610               | 4,663,263                    |
| DEHYDRATORS        | 880,047                 | 492,319                      | 63,101               | 924,049                 | 516,935                      |
| GAGES              | 1,883,986               | 1,272,369                    | 99,538               | 1,993,690               | 1,351,493                    |
| TESTING EQUIP      | 2,776,803               | 1,752,445                    | 166,709              | 2,915,643               | 1,840,068                    |
| FILTERS            | 5,260,514               | 3,412,867                    | 300,696              | 5,547,155               | 3,607,125                    |
| PANELS             | 7,031,506               | 4,528,230                    | 407,397              | 7,409,798               | 4,781,358                    |

I.1 1987 - 1989 Summary Estimated Costs for Non-Standardization (Uninflated)

| Nomenclature           | Total 1987<br>Est Costs | 1987 Non-<br>Recurring Costs | 1987 Annual<br>Costs | Total 1988<br>Est Costs | 1988 Non-<br>Recurring Costs |
|------------------------|-------------------------|------------------------------|----------------------|-------------------------|------------------------------|
| ISOLATORS              | 50,367                  | 14,248                       | 5,878                | 52,885                  | 14,961                       |
| HYDRAIC EQUIP          | 11,628,248              | 7,193,610                    | 721,717              | 13,711,721              | 8,497,943                    |
| CAPSTANS               | 495,723                 | 211,734                      | 46,218               | 507,065                 | 213,955                      |
| REELS                  | 1,112,751               | 707,382                      | 65,972               | 1,285,069               | 819,278                      |
| DAVITS                 | 218,566                 | 87,591                       | 21,316               | 229,971                 | 92,447                       |
| CRANES                 | 1,806,211               | 830,670                      | 158,765              | 1,896,521               | 872,204                      |
| HOISTS                 | 1,698,639               | 1,063,326                    | 103,394              | 1,783,571               | 1,116,492                    |
| ELEVATORS              | 862,176                 | 526,143                      | 54,688               | 905,284                 | 552,450                      |
| STEERING EQUIP         | 727,272                 | 463,369                      | 42,949               | 763,636                 | 486,537                      |
| CONTROL EQUIP          | 11,440,667              | 7,352,628                    | 665,310              | 12,053,133              | 7,760,691                    |
| WINCHES                | 4,135,294               | 2,529,199                    | 261,385              | 4,794,115               | 2,943,894                    |
| WINDLASSES             | 559,141                 | 275,685                      | 46,131               | 587,098                 | 289,469                      |
| FIREFIGHTING EQUIP     | 2,892,119               | 1,816,631                    | 175,031              | 3,036,725               | 1,907,463                    |
| LUBRICATORS            | 383,928                 | 246,001                      | 22,447               | 404,794                 | 259,971                      |
| ENGINES                | 46,924,275              | 29,497,472                   | 2,336,132            | 49,270,489              | 30,972,346                   |
| PLUMBING EQUIP         | 242,324                 | 159,586                      | 13,563               | 256,262                 | 168,756                      |
| GEARS AND REDUCERS     | 4,060,198               | 2,435,847                    | 264,356              | 4,263,208               | 2,557,640                    |
| GOVERNORS              | 9,217,447               | 5,792,738                    | 557,356              | 10,803,576              | 6,794,355                    |
| IGNITION EQUIP         | 31,003                  | 9,493                        | 3,501                | 32,553                  | 9,968                        |
| EJECTORS               | 290,790                 | 149,246                      | 23,036               | 305,926                 | 157,305                      |
| EDUCTORS               | 71,731                  | 40,590                       | 5,068                | 82,645                  | 48,254                       |
| STRAINERS              | 1,024,089               | 726,163                      | 48,486               | 1,088,055               | 775,233                      |
| PURIFIERS              | 6,368,981               | 3,970,873                    | 390,281              | 6,687,430               | 4,169,417                    |
| TRAPS-STEAM            | 172,991                 | 118,791                      | 8,821                | 183,310                 | 126,400                      |
| COUPLINGS              | 1,000,099               | 682,120                      | 64,769               | 1,252,799               | 801,354                      |
| SILENCING EQUIP        | 76,017                  | 51,478                       | 3,994                | 80,653                  | 54,887                       |
| BRAKES                 | 708,046                 | 467,342                      | 39,173               | 748,338                 | 495,599                      |
| BLOWERS                | 1,196,723               | 728,162                      | 76,256               | 1,256,559               | 764,570                      |
| WELDING SYSTEMS        | 1,815,905               | 1,147,350                    | 108,804              | 1,906,700               | 1,204,717                    |
| BOAT PROPULSION        | 902,893                 | 431,851                      | 76,660               | 951,139                 | 456,544                      |
| DECK MACHINERY         | 1,423,476               | 900,271                      | 83,847               | 1,500,375               | 959,409                      |
| PHOTOGRAPHIC EQUIP     | 96,377                  | 63,042                       | 5,425                | 101,554                 | 66,552                       |
| UNDERWATER LOG EQUIP   | 215,772                 | 114,138                      | 16,540               | 226,560                 | 119,845                      |
| VALVES                 | 33,049,257              | 22,113,978                   | 1,779,666            | 34,936,440              | 23,454,397                   |
| MISC PARTS             | 36,758,683              | 23,298,548                   | 2,190,575            | 38,596,617              | 24,463,476                   |
| LAUNDRY EQUIP          | 17,385,312              | 11,040,254                   | 1,032,629            | 20,545,488              | 13,049,759                   |
| TANKS                  | 704,648                 | 317,843                      | 62,951               | 742,623                 | 336,478                      |
| PIPE, HOSE, & FITTINGS | 108,509                 | 49,792                       | 9,556                | 114,411                 | 52,758                       |
| ASW EQUIP              | 1,419,541               | 857,356                      | 31,412               | 1,490,518               | 900,748                      |
| YELLOW GEAR            | 31,940,338              | 20,763,798                   | 1,318,330            | 33,681,312              | 21,945,945                   |
| PERISCOPES             | 579,470                 | 338,154                      | 39,273               | 608,444                 | 355,062                      |
| MISC EQUIP             | 1,022,997               | 677,607                      | 56,211               | 1,080,468               | 717,809                      |
| GRAND TOTALS           | 415,842,887             | 263,975,488                  | 24,715,720           | 448,009,771             | 284,769,963                  |



I.1 1987 - 1989 Summary Estimated Costs for Non-Standardization (Uninflated)

| Nomenclature       | 1988 Annual<br>Costs | Total 1989<br>Est Costs | 1989 Non-<br>Recurring Costs | 1989 Annual<br>Costs |
|--------------------|----------------------|-------------------------|------------------------------|----------------------|
| PUMPS              | 1,299,926            | 22,748,876              | 14,362,819                   | 1,364,922            |
| BOILERS            | 141,834              | 2,297,892               | 1,382,886                    | 148,926              |
| HEAT EXCHANGERS    | 88,892               | 1,451,167               | 929,269                      | 84,936               |
| CONDENSERS         | 26,583               | 389,849                 | 218,855                      | 27,828               |
| TURBINES           | 498,872              | 7,341,639               | 4,128,184                    | 522,975              |
| COMPRESSORS        | 742,288              | 12,892,893              | 8,184,321                    | 779,318              |
| HEATERS            | 137,411              | 2,784,115               | 1,897,578                    | 144,281              |
| DISTILLING PLANTS  | 47,541               | 661,939                 | 355,216                      | 49,918               |
| BATTERY CHARGERS   | 63,599               | 1,188,886               | 697,758                      | 66,779               |
| METERS             | 13,369               | 258,885                 | 171,833                      | 14,837               |
| CONVERTERS         | 156,189              | 2,623,768               | 1,616,584                    | 163,915              |
| TRANSFORMERS       | 1,919                | 55,979                  | 43,596                       | 2,815                |
| CIRCUIT BREAKERS   | 237,782              | 4,428,293               | 2,886,686                    | 249,587              |
| CONTROLLERS        | 2,458,864            | 49,968,613              | 31,674,274                   | 2,977,328            |
| GENERATORS         | 272,427              | 3,228,993               | 3,828,248                    | 423,261              |
| MOTORS             | 788,516              | 15,838,851              | 18,383,128                   | 819,542              |
| MOTOR GENERATORS   | 49,463               | 592,449                 | 273,321                      | 51,937               |
| RELAYS             | 46,188               | 939,148                 | 641,328                      | 48,468               |
| RHEOSTATS          | 5,586                | 186,546                 | 78,589                       | 5,865                |
| SWITCHES           | 313,978              | 7,614,233               | 5,299,521                    | 376,789              |
| SWITCHBOARDS       | 182,478              | 3,282,783               | 2,825,394                    | 191,682              |
| VISUAL ALARMS      | 17,713               | 345,948                 | 231,657                      | 18,599               |
| LIGHTING FIXTURES  | 38,211               | 615,978                 | 421,862                      | 31,722               |
| GYRO COMPASSES     | 127,748              | 2,171,253               | 1,347,899                    | 134,127              |
| PROJECTION EQUIP   | 24,368               | 432,931                 | 275,714                      | 25,586               |
| I/C EQUIP          | 119,568              | 2,881,663               | 1,318,287                    | 125,538              |
| NAVIGATIONAL EQUIP | 383,783              | 6,419,835               | 4,875,693                    | 381,498              |
| INJECTORS          | 14,323               | 239,419                 | 147,818                      | 15,839               |
| BURNERS            | 46,812               | 658,978                 | 356,957                      | 49,153               |
| MARINE HARDWARE    | 52,398               | 981,754                 | 643,747                      | 55,889               |
| REFRIG EQUIP       | 765,118              | 16,849,669              | 18,448,859                   | 912,888              |
| AIR CONDITIONING   | 57,976               | 1,813,388               | 639,977                      | 68,778               |
| STARTERS           | 76,533               | 1,263,572               | 769,797                      | 88,368               |
| WIPERS             | 13,369               | 243,957                 | 157,788                      | 14,838               |
| AUDIBLE ALARMS     | 23,299               | 368,976                 | 218,658                      | 24,463               |
| BEARINGS           | 29,718               | 387,629                 | 195,897                      | 31,284               |
| INDICATORS         | 256,438              | 4,755,398               | 3,188,913                    | 269,268              |
| CLUTCHES           | 61,762               | 746,141                 | 347,666                      | 64,858               |
| FANS               | 32,164               | 774,874                 | 567,359                      | 33,772               |
| SHOP EQUIP         | 247,361              | 7,178,417               | 4,741,845                    | 396,671              |
| REGULATORS         | 67,881               | 1,164,384               | 732,838                      | 78,351               |
| GALLEY EQUIP       | 425,798              | 7,678,448               | 4,923,276                    | 447,888              |
| DEHYDRATORS        | 66,256               | 978,252                 | 542,782                      | 69,569               |
| GAGES              | 184,515              | 2,118,578               | 1,436,262                    | 189,748              |
| TESTING EQUIP      | 175,845              | 3,861,425               | 1,932,871                    | 183,797              |
| FILTERS            | 315,731              | 5,858,781               | 3,813,678                    | 331,517              |
| PANELS             | 427,766              | 7,889,915               | 5,858,853                    | 449,155              |

I.1 1987 - 1989 Summary Estimated Costs for Non-Standardization (Uninflated)

| Nomenclature           | 1988 Annual<br>Costs | Total 1989<br>Est Costs | 1989 Non-<br>Recurring Costs | 1989 Annual<br>Costs |
|------------------------|----------------------|-------------------------|------------------------------|----------------------|
| ISOLATORS              | 6,172                | 55,530                  | 15,709                       | 6,481                |
| HYDRALIC EQUIP         | 848,518              | 17,187,673              | 10,677,714                   | 1,059,466            |
| CAPSTANS               | 47,702               | 643,505                 | 296,212                      | 56,520               |
| REELS                  | 75,805               | 1,564,362               | 1,000,688                    | 91,735               |
| DAVITS                 | 22,381               | 241,999                 | 97,599                       | 23,501               |
| CRANES                 | 166,703              | 1,991,347               | 915,814                      | 175,038              |
| HOISTS                 | 108,564              | 1,972,749               | 1,172,317                    | 113,992              |
| ELEVATORS              | 57,422               | 950,549                 | 580,073                      | 60,293               |
| STEERING EQUIP         | 45,097               | 901,918                 | 510,964                      | 47,351               |
| CONTROL EQUIP          | 698,575              | 12,700,628              | 8,193,564                    | 733,504              |
| WINCHES                | 301,115              | 5,873,603               | 3,626,540                    | 365,699              |
| WINDLASSES             | 48,438               | 616,453                 | 303,943                      | 50,060               |
| FIREFIGHTING EQUIP     | 183,782              | 3,188,561               | 2,002,836                    | 192,971              |
| LUBRICATORS            | 23,569               | 426,885                 | 274,821                      | 24,748               |
| ENGINES                | 2,977,939            | 51,734,013              | 32,520,963                   | 3,126,835            |
| PLUMBING EQUIP         | 14,241               | 270,398                 | 178,518                      | 14,953               |
| GEARS AND REDUCERS     | 277,573              | 4,476,368               | 2,685,522                    | 291,452              |
| GOVERNORS              | 652,482              | 13,434,137              | 8,456,713                    | 810,053              |
| IGNITION EQUIP         | 3,676                | 34,181                  | 10,466                       | 3,859                |
| EJECTORS               | 24,187               | 321,884                 | 165,831                      | 25,397               |
| EDUCTORS               | 5,597                | 100,172                 | 60,917                       | 6,389                |
| STRAINERS              | 50,910               | 1,156,610               | 828,147                      | 53,456               |
| PURIFIERS              | 409,795              | 7,021,801               | 4,377,887                    | 430,285              |
| TRAPS-STEAM            | 9,262                | 194,327                 | 134,572                      | 9,725                |
| COUPLINGS              | 73,470               | 1,532,128               | 995,755                      | 87,292               |
| SILENCING EQUIP        | 4,193                | 85,612                  | 58,557                       | 4,403                |
| BRAKES                 | 41,132               | 791,178                 | 525,802                      | 43,189               |
| BLOWERS                | 80,069               | 1,319,387               | 802,798                      | 84,072               |
| WELDING SYSTEMS        | 114,245              | 2,002,035               | 1,264,953                    | 119,957              |
| BOAT PROPULSION        | 80,493               | 1,002,134               | 482,810                      | 84,518               |
| DECK MACHINERY         | 88,040               | 1,581,743               | 1,013,728                    | 92,442               |
| PHOTOGRAPHIC EQUIP     | 5,696                | 107,029                 | 70,277                       | 5,981                |
| UNDERWATER LOG EQUIP   | 17,367               | 237,888                 | 125,837                      | 18,236               |
| VALVES                 | 1,868,650            | 36,943,564              | 24,887,419                   | 1,962,082            |
| MISC PARTS             | 2,300,104            | 40,526,448              | 25,686,649                   | 2,415,109            |
| LAUNDRY EQUIP          | 1,219,895            | 25,828,569              | 16,409,818                   | 1,532,858            |
| TANKS                  | 66,098               | 782,796                 | 356,344                      | 69,403               |
| PIPE, HOSE, & FITTINGS | 10,034               | 120,661                 | 55,925                       | 10,535               |
| ASW EQUIP              | 95,982               | 1,565,044               | 945,786                      | 100,781              |
| YELLOW GEAR            | 1,909,877            | 35,525,024              | 23,202,889                   | 2,005,371            |
| PERISCOPES             | 41,237               | 638,866                 | 372,815                      | 43,299               |
| MISC EQUIP             | 59,021               | 1,141,502               | 760,710                      | 61,972               |
| GRAND TOTALS           | 26,566,527           | 497,467,845             | 316,719,951                  | 29,415,887           |

I.2 1987 - 1989 Duplication Reduction Savings (Uninflated)

| Nomenclature       | Duplicate         | 1987 Annual Parts | 1988 Annual Parts | 1989 Annual Parts |
|--------------------|-------------------|-------------------|-------------------|-------------------|
|                    | Reduction Savings | Reduction Savings | Reduction Savings | Reduction Savings |
| PUMPS              | 966,459           | 72,741            | 76,378            | 80,197            |
| BOILERS            | 163,131           | 27,467            | 28,841            | 30,283            |
| HEAT EXCHANGERS    | 110,107           | 11,785            | 12,374            | 12,993            |
| CONDENSERS         | 64,808            | 11,074            | 11,628            | 12,209            |
| TURBINES           | 927,605           | 167,113           | 175,468           | 184,242           |
| COMPRESSORS        | 494,831           | 56,750            | 59,587            | 62,567            |
| HEATERS            | 97,090            | 7,799             | 8,189             | 8,598             |
| DISTILLING PLANTS  | 57,645            | 20,091            | 21,095            | 22,150            |
| BATTERY CHARGERS   | 37,101            | 6,907             | 7,252             | 7,615             |
| METERS             | 13,242            | 3,717             | 3,902             | 4,098             |
| CONVERTERS         | 124,815           | 17,021            | 17,872            | 18,766            |
| TRANSFORMERS       | 7,141             | 540               | 567               | 595               |
| CIRCUIT BREAKERS   | 301,971           | 11,729            | 12,316            | 12,932            |
| CONTROLLERS        | 1,436,175         | 107,786           | 124,135           | 150,700           |
| GENERATORS         | 182,425           | 101,142           | 104,981           | 117,146           |
| MOTORS             | 536,421           | 41,431            | 43,503            | 45,678            |
| MOTOR GENERATORS   | 62,827            | 31,653            | 33,236            | 34,897            |
| RELAYS             | 58,862            | 2,462             | 2,585             | 2,714             |
| RHEOSTATS          | 20,130            | 1,026             | 1,078             | 1,132             |
| SWITCHES           | 281,844           | 14,322            | 16,314            | 19,501            |
| SWITCHBOARDS       | 332,247           | 17,091            | 17,946            | 18,843            |
| VISUAL ALARMS      | 28,623            | 1,415             | 1,485             | 1,560             |
| LIGHTING FIXTURES  | 39,449            | 1,503             | 1,662             | 1,745             |
| GYRO COMPASSES     | 239,775           | 12,899            | 13,544            | 14,222            |
| PROJECTION EQUIP   | 31,584            | 1,170             | 1,228             | 1,290             |
| I/C EQUIP          | 159,247           | 8,543             | 8,970             | 9,419             |
| NAVIGATIONAL EQUIP | 110,578           | 13,448            | 15,820            | 19,766            |
| INJECTORS          | 15,909            | 2,479             | 2,603             | 2,733             |
| BURNERS            | 47,264            | 18,824            | 19,766            | 20,754            |
| MARINE HARDWARE    | 97,259            | 4,102             | 4,307             | 4,522             |
| REFRIG EQUIP       | 270,374           | 44,897            | 50,112            | 58,134            |
| AIR CONDITIONING   | 24,526            | 6,751             | 7,089             | 7,443             |
| STARTERS           | 58,817            | 12,786            | 13,425            | 14,096            |
| WIPERS             | 19,003            | 712               | 748               | 785               |
| AUDIBLE ALARMS     | 14,639            | 7,879             | 8,273             | 8,686             |
| BEARINGS           | 41,757            | 18,285            | 19,200            | 20,160            |
| INDICATORS         | 168,105           | 13,832            | 14,523            | 15,249            |
| CLUTCHES           | 56,986            | 37,069            | 38,923            | 40,869            |
| FANS               | 37,724            | 4,302             | 4,517             | 4,742             |
| SHOP EQUIP         | 196,456           | 14,664            | 13,992            | 21,579            |
| REGULATORS         | 122,298           | 4,566             | 4,794             | 5,034             |
| GALLEY EQUIP       | 219,346           | 27,875            | 29,269            | 30,732            |
| DEHYDRATORS        | 61,278            | 22,174            | 23,282            | 24,446            |
| GAGES              | 125,094           | 6,521             | 6,847             | 7,190             |
| TESTING EQUIP      | 80,167            | 11,014            | 11,565            | 12,143            |
| FILTERS            | 272,957           | 17,353            | 18,221            | 19,132            |
| PANELS             | 391,000           | 22,737            | 23,874            | 25,068            |

I.2 1987 - 1989 Duplication Reduction Savings (Uninflated)

| Nomenclature           | Duplicate         | 1987 Annual Parts | 1988 Annual Parts | 1989 Annual Parts |
|------------------------|-------------------|-------------------|-------------------|-------------------|
|                        | Reduction Savings | Reduction Savings | Reduction Savings | Reduction Savings |
| ISOLATORS              | 6,942             | 5,878             | 6,172             | 6,481             |
| HYDRALIC EQUIP         | 277,553           | 72,988            | 81,210            | 93,765            |
| CAPSTANS               | 49,057            | 33,766            | 35,413            | 37,508            |
| REELS                  | 32,976            | 5,945             | 6,572             | 7,513             |
| DAVITS                 | 27,252            | 17,309            | 18,174            | 19,083            |
| CRANES                 | 183,039           | 102,096           | 107,201           | 112,561           |
| HOISTS                 | 106,659           | 8,231             | 8,643             | 9,075             |
| ELEVATORS              | 153,816           | 10,040            | 10,542            | 11,069            |
| STEERING EQUIP         | 57,152            | 2,165             | 2,273             | 2,387             |
| CONTROL EQUIP          | 671,183           | 34,657            | 36,390            | 38,209            |
| WINCHES                | 180,490           | 45,413            | 49,027            | 53,975            |
| WINDLASSES             | 68,102            | 26,097            | 27,402            | 28,772            |
| FIREFIGHTING EQUIP     | 53,026            | 11,894            | 12,489            | 13,113            |
| LUBRICATORS            | 20,567            | 2,413             | 2,533             | 2,660             |
| ENGINES                | 1,752,331         | 215,639           | 226,421           | 237,742           |
| PLUMBING EQUIP         | 17,706            | 684               | 718               | 754               |
| GEARS AND REDUCERS     | 343,004           | 56,857            | 59,700            | 62,685            |
| GOVERNORS              | 217,188           | 40,230            | 45,632            | 54,212            |
| IGNITION EQUIP         | 4,199             | 3,501             | 3,676             | 3,859             |
| EJECTORS               | 59,018            | 12,303            | 12,918            | 13,564            |
| EDUCTORS               | 8,868             | 3,353             | 3,535             | 3,738             |
| STRAINERS              | 95,616            | 2,550             | 2,678             | 2,812             |
| PURIFIERS              | 212,617           | 40,538            | 42,565            | 44,694            |
| TRAPS-STEAM            | 31,191            | 807               | 847               | 890               |
| COUPLINGS              | 46,336            | 20,087            | 21,366            | 22,946            |
| SILENCING EQUIP        | 4,498             | 988               | 1,038             | 1,090             |
| BRAKES                 | 39,838            | 3,970             | 4,169             | 4,377             |
| BLOWERS                | 99,127            | 13,148            | 13,805            | 14,496            |
| WELDING SYSTEMS        | 52,967            | 5,484             | 5,758             | 6,046             |
| BOAT PROPULSION        | 97,566            | 50,615            | 53,146            | 55,803            |
| DECK MACHINERY         | 143,231           | 8,289             | 8,704             | 9,139             |
| PHOTOGRAPHIC EQUIP     | 6,563             | 273               | 287               | 301               |
| UNDERWATER LOG EQUIP   | 54,669            | 7,954             | 8,352             | 8,770             |
| VALVES                 | 2,700,763         | 89,912            | 94,407            | 99,128            |
| MISC PARTS             | 1,166,994         | 111,582           | 117,161           | 123,019           |
| LAUNDRY EQUIP          | 126,011           | 58,406            | 68,163            | 84,272            |
| TANKS                  | 74,637            | 46,494            | 48,819            | 51,260            |
| PIPE, HOSE, & FITTINGS | 11,368            | 7,266             | 7,630             | 8,011             |
| ASW EQUIP              | 40,698            | 16,998            | 17,948            | 18,741            |
| YELLOW GEAR            | 135,740           | 91,683            | 96,267            | 101,081           |
| PERISCOPES             | 99,925            | 10,939            | 11,486            | 12,060            |
| MISC EQUIP             | 91,012            | 3,120             | 3,276             | 3,439             |
| GRAND TOTALS           | 18,828,660        | 2,372,092         | 2,521,696         | 2,724,449         |

## APPENDIX J: INVENTORY DEPTH INCREASE

Appendix J provides the estimates for the number of parts that can be added to inventory depth based on the standardization assumptions described in Chapter IV. It is in two parts. The first shows the potential inventory increases resulting from savings achieved by reduction of duplicate parts currently in the system. It also provides the inventory increases that result from savings realized by standardizing parts entering the Navy Supply System in 1987. The second part continues the latter assessment for 1988 and 1989.

Potential Inventory Increase

| Nomenclature       | Cost/<br>Part | Inventory<br>Range | Dup Parts<br>Funds Avail | Dup Addnl<br>Parts/Range | 1987 Annual<br>Funds Avail | Total 1987<br>Funds Avail | 1987 Addnl<br>Parts/Range |
|--------------------|---------------|--------------------|--------------------------|--------------------------|----------------------------|---------------------------|---------------------------|
| PUMPS              | 527           | 31,450             | 604,837                  | 0.030                    | 409,614                    | 4,480,481                 | 0.222                     |
| BOILERS            | 190           | 4,653              | 101,357                  | 0.095                    | 50,796                     | 442,521                   | 0.411                     |
| HEAT EXCHANGERS    | 856           | 3,350              | 58,817                   | 0.020                    | 27,758                     | 286,996                   | 0.082                     |
| CONDENSERS         | 944           | 1,793              | 40,505                   | 0.020                    | 11,349                     | 72,580                    | 0.035                     |
| TURBINES           | 1,098         | 25,566             | 579,753                  | 0.017                    | 200,458                    | 1,370,578                 | 0.040                     |
| COMPRESSORS        | 238           | 15,554             | 309,270                  | 0.069                    | 238,629                    | 2,535,772                 | 0.564                     |
| HEATERS            | 208           | 3,154              | 60,681                   | 0.076                    | 43,333                     | 568,639                   | 0.712                     |
| DISTILLING PLANTS  | 364           | 1,280              | 36,029                   | 0.024                    | 20,427                     | 121,112                   | 0.081                     |
| BATTERY CHARGERS   | 223           | 1,088              | 23,188                   | 0.079                    | 21,087                     | 217,339                   | 0.738                     |
| METERS             | 388           | 329                | 3,276                    | 0.023                    | 5,140                      | 52,313                    | 0.147                     |
| CONVERTERS         | 359           | 3,778              | 78,010                   | 0.047                    | 51,780                     | 509,996                   | 0.309                     |
| TRANSFORMERS       | 388           | 220                | 4,463                    | 0.043                    | 740                        | 12,440                    | 0.120                     |
| CIRCUIT BREAKERS   | 28            | 9,328              | 188,732                  | 0.567                    | 74,410                     | 881,684                   | 2.647                     |
| CONTROLLERS        | 31            | 47,248             | 897,310                  | 0.506                    | 698,397                    | 7,769,785                 | 4.382                     |
| GENERATORS         | 4,429         | 2,392              | 114,016                  | 0.007                    | 119,981                    | 310,167                   | 0.050                     |
| MOTORS             | 687           | 17,518             | 335,263                  | 0.023                    | 245,244                    | 3,235,752                 | 0.221                     |
| MOTOR GENERATORS   | 2,114         | 1,053              | 39,267                   | 0.015                    | 24,613                     | 101,428                   | 0.037                     |
| RELAYS             | 43            | 1,929              | 36,789                   | 0.368                    | 14,507                     | 192,056                   | 1.323                     |
| RHEOSTATS          | 131           | 636                | 12,581                   | 0.124                    | 1,983                      | 21,531                    | 0.212                     |
| SWITCHES           | 101           | 9,260              | 176,153                  | 0.155                    | 90,387                     | 1,265,543                 | 1.116                     |
| SWITCHBOARDS       | 481           | 10,646             | 207,655                  | 0.033                    | 59,650                     | 628,413                   | 0.101                     |
| VISUAL ALARMS      | 82            | 923                | 17,890                   | 0.196                    | 5,714                      | 70,063                    | 0.767                     |
| LIGHTING FIXTURES  | 23            | 1,294              | 24,656                   | 0.682                    | 9,486                      | 126,061                   | 3.485                     |
| GYRO COMPASSES     | 154           | 7,657              | 149,860                  | 0.104                    | 42,049                     | 423,880                   | 0.295                     |
| PROJECTION EQUIP   | 0             | 1,040              | 19,740                   | 0.000                    | 7,618                      | 85,758                    | 0.000                     |
| I/C EQUIP          | 152           | 5,144              | 99,529                   | 0.105                    | 38,253                     | 409,650                   | 0.432                     |
| NAVIGATIONAL EQUIP | 9             | 3,623              | 69,111                   | 1.674                    | 84,559                     | 942,885                   | 22.835                    |
| INJECTORS          | 60            | 462                | 9,943                    | 0.297                    | 5,037                      | 46,707                    | 1.395                     |
| BURNERS            | 399           | 981                | 29,540                   | 0.062                    | 19,815                     | 120,993                   | 0.254                     |
| MARINE HARDWARE    | 172           | 3,146              | 60,787                   | 0.092                    | 16,874                     | 196,423                   | 0.299                     |
| REFRIG EQUIP       | 953           | 8,518              | 168,984                  | 0.017                    | 224,208                    | 2,589,888                 | 0.263                     |
| AIR CONDITIONING   | 265           | 670                | 15,329                   | 0.071                    | 19,335                     | 198,836                   | 0.323                     |
| STARTERS           | 263           | 1,620              | 36,761                   | 0.071                    | 26,773                     | 244,970                   | 0.473                     |
| WIPERS             | 4             | 623                | 11,877                   | 3.600                    | 4,202                      | 48,463                    | 14.688                    |
| AUDIBLE ALARMS     | 586           | 248                | 9,150                    | 0.052                    | 9,396                      | 68,377                    | 0.388                     |
| BEARINGS           | 2,921         | 790                | 26,098                   | 0.009                    | 14,559                     | 69,063                    | 0.025                     |
| INDICATORS         | 132           | 5,480              | 105,066                  | 0.120                    | 80,643                     | 947,936                   | 1.080                     |
| CLUTCHES           | 1,555         | 694                | 35,616                   | 0.027                    | 29,966                     | 128,510                   | 0.098                     |
| FANS               | 1,195         | 1,146              | 23,577                   | 0.014                    | 10,917                     | 165,218                   | 0.099                     |
| SHOP EQUIP         | 156           | 6,416              | 122,785                  | 0.101                    | 86,589                     | 1,049,879                 | 0.365                     |
| REGULATORS         | 65            | 3,378              | 76,430                   | 0.243                    | 21,367                     | 228,959                   | 0.729                     |
| GALLEY EQUIP       | 495           | 6,962              | 137,091                  | 0.033                    | 135,437                    | 1,516,107                 | 0.362                     |
| DEHYDRATORS        | 748           | 1,359              | 38,298                   | 0.031                    | 26,648                     | 180,498                   | 0.146                     |
| GAGES              | 261           | 4,065              | 78,184                   | 0.061                    | 33,143                     | 430,759                   | 0.335                     |
| TESTING EQUIP      | 141           | 2,548              | 50,105                   | 0.114                    | 55,539                     | 603,178                   | 1.378                     |
| FILTERS            | 190           | 8,908              | 170,598                  | 0.083                    | 99,390                     | 1,165,911                 | 0.566                     |
| PANELS             | 159           | 12,795             | 244,425                  | 0.099                    | 134,417                    | 1,549,489                 | 0.627                     |

Potential Inventory Increase

| Nomenclature           | Cost/<br>Part | Inventory<br>Range | Dup Parts<br>Funds Avail | Dup Addnl<br>Parts/Range | 1987 Annual<br>Funds Avail | Total 1987<br>Funds Avail | 1987 Addnl<br>Parts/Range |
|------------------------|---------------|--------------------|--------------------------|--------------------------|----------------------------|---------------------------|---------------------------|
| ISOLATORS              | 691           | 35                 | 4,339                    | 0.148                    | 3,674                      | 8,126                     | 0.276                     |
| HYDRALIC EQUIP         | 1,379         | 7,866              | 173,470                  | 0.013                    | 248,345                    | 2,496,349                 | 0.189                     |
| CAPSTANS               | 1,816         | 525                | 30,661                   | 0.026                    | 24,995                     | 91,162                    | 0.079                     |
| REELS                  | 175           | 995                | 20,610                   | 0.098                    | 22,474                     | 243,531                   | 1.154                     |
| DAVITS                 | 2,009         | 334                | 17,032                   | 0.021                    | 12,070                     | 39,442                    | 0.048                     |
| CRANES                 | 2,264         | 2,763              | 114,399                  | 0.015                    | 81,519                     | 341,103                   | 0.045                     |
| HOISTS                 | 138           | 3,406              | 66,662                   | 0.117                    | 34,883                     | 367,172                   | 0.644                     |
| ELEVATORS              | 243           | 4,810              | 96,135                   | 0.068                    | 20,227                     | 184,647                   | 0.130                     |
| STEERING EQUIP         | 0             | 1,981              | 35,720                   | 0.000                    | 14,098                     | 158,901                   | 0.000                     |
| CONTROL EQUIP          | 75            | 22,051             | 419,489                  | 0.209                    | 218,740                    | 2,516,436                 | 1.256                     |
| WINCHES                | 1,074         | 4,823              | 112,806                  | 0.018                    | 95,874                     | 886,249                   | 0.141                     |
| WINDLASSES             | 588           | 1,418              | 42,564                   | 0.042                    | 22,571                     | 108,723                   | 0.107                     |
| FIREFIGHTING EQUIP     | 140           | 1,639              | 33,141                   | 0.119                    | 58,414                     | 626,111                   | 2.244                     |
| LUBRICATORS            | 111           | 633                | 12,854                   | 0.151                    | 7,769                      | 84,644                    | 0.992                     |
| ENGINES                | 144           | 55,154             | 1,095,207                | 0.113                    | 953,678                    | 10,171,638                | 1.051                     |
| PLUMBING EQUIP         | 0             | 583                | 11,066                   | 0.000                    | 4,452                      | 54,323                    | 0.000                     |
| GEARS AND REDUCERS     | 1,301         | 9,780              | 214,378                  | 0.014                    | 100,379                    | 861,581                   | 0.056                     |
| GOVERNORS              | 152           | 6,728              | 135,743                  | 0.109                    | 186,746                    | 1,996,976                 | 1.603                     |
| IGNITION EQUIP         | 125           | 23                 | 2,625                    | 0.750                    | 2,188                      | 5,155                     | 1.472                     |
| EJECTORS               | 644           | 1,556              | 36,886                   | 0.030                    | 11,043                     | 57,683                    | 0.047                     |
| EDUCTORS               | 1,342         | 185                | 5,543                    | 0.018                    | 2,632                      | 15,316                    | 0.051                     |
| STRAINERS              | 31            | 3,143              | 59,760                   | 0.510                    | 15,949                     | 242,875                   | 2.073                     |
| PURIFIERS              | 192           | 6,275              | 132,886                  | 0.091                    | 134,631                    | 1,375,529                 | 0.938                     |
| TRAPS-STEAM            | 79            | 1,014              | 19,494                   | 0.201                    | 3,009                      | 40,131                    | 0.415                     |
| COUPLINGS              | 3,644         | 942                | 28,960                   | 0.007                    | 26,517                     | 239,680                   | 0.057                     |
| SILENCING EQUIP        | 227           | 121                | 2,811                    | 0.004                    | 1,557                      | 17,644                    | 0.529                     |
| BRAKES                 | 288           | 1,242              | 24,899                   | 0.057                    | 13,482                     | 159,527                   | 0.367                     |
| BLOWERS                | 165           | 2,940              | 61,954                   | 0.105                    | 27,939                     | 255,489                   | 0.435                     |
| WELDING SYSTEMS        | 0             | 1,743              | 33,104                   | 0.000                    | 35,715                     | 394,262                   | 0.000                     |
| BOAT PROPULSION        | 5,786         | 1,591              | 60,979                   | 0.005                    | 39,774                     | 174,727                   | 0.016                     |
| DECK MACHINERY         | 320           | 4,573              | 89,520                   | 0.050                    | 28,793                     | 312,627                   | 0.176                     |
| PHOTOGRAPHIC EQUIP     | 0             | 216                | 4,102                    | 0.000                    | 1,781                      | 21,482                    | 0.000                     |
| UNDERWATER LOG EQUIP   | 206           | 1,553              | 34,168                   | 0.008                    | 7,655                      | 43,323                    | 0.112                     |
| VALVES                 | 30            | 88,881             | 1,687,977                | 0.521                    | 584,243                    | 7,494,861                 | 2.312                     |
| MISC PARTS             | 16            | 30,368             | 729,371                  | 0.991                    | 719,424                    | 8,000,220                 | 10.870                    |
| LAUNDRY EQUIP          | 197           | 3,927              | 78,757                   | 0.004                    | 340,948                    | 3,791,028                 | 4.038                     |
| TANKS                  | 7,506         | 955                | 46,648                   | 0.005                    | 34,201                     | 133,527                   | 0.015                     |
| PIPE, HOSE, & FITTINGS | 1,470         | 139                | 7,105                    | 0.029                    | 5,257                      | 20,817                    | 0.004                     |
| ASW EQUIP              | 0             | 910                | 25,436                   | 0.111                    | 33,878                     | 301,958                   | 1.322                     |
| YELLOW GEAR            | 0             | 4,468              | 84,837                   | 0.000                    | 597,067                    | 7,085,754                 | 0.000                     |
| PERISCOPES             | 235           | 2,978              | 62,453                   | 0.073                    | 15,691                     | 121,364                   | 0.143                     |
| MISC EQUIP             | 35            | 2,986              | 56,883                   | 0.442                    | 18,541                     | 230,293                   | 1.791                     |
| GRAND TOTALS           | 736           | 580,657            | 11,767,913               |                          | 8,464,941                  | 90,957,281                |                           |
| Ave Depth Inc          |               |                    | 0.023                    |                          | 0.016                      | 0.175                     |                           |
| Ave # Parts            |               |                    | 13,154                   |                          | 9,462                      | 101,672                   |                           |

Potential Inventory Increase

| Nomenclature       | 1988 Annual<br>Funds Avail | Total 1988<br>Funds Avail | 1988 Addnl<br>Parts/Range | 1989 Annual<br>Funds Avail | Total 1989<br>Funds Avail | 1989 Addnl<br>Parts/Range |
|--------------------|----------------------------|---------------------------|---------------------------|----------------------------|---------------------------|---------------------------|
| PUMPS              | 430,095                    | 4,704,506                 | 0.222                     | 451,600                    | 4,939,731                 | 0.222                     |
| BOILERS            | 53,336                     | 464,647                   | 0.411                     | 56,003                     | 487,880                   | 0.411                     |
| HEAT EXCHANGERS    | 29,146                     | 303,470                   | 0.083                     | 30,603                     | 321,000                   | 0.084                     |
| CONDENSERS         | 11,916                     | 76,618                    | 0.035                     | 12,512                     | 80,904                    | 0.036                     |
| TURBINES           | 210,481                    | 1,439,107                 | 0.040                     | 221,005                    | 1,511,063                 | 0.040                     |
| COMPRESSORS        | 250,561                    | 2,662,561                 | 0.564                     | 263,089                    | 2,795,689                 | 0.564                     |
| HEATERS            | 45,500                     | 603,402                   | 0.719                     | 47,775                     | 640,766                   | 0.728                     |
| DISTILLING PLANTS  | 21,449                     | 127,168                   | 0.081                     | 22,521                     | 133,526                   | 0.081                     |
| BATTERY CHANGERS   | 22,141                     | 228,823                   | 0.741                     | 23,248                     | 241,298                   | 0.744                     |
| METERS             | 5,397                      | 55,711                    | 0.149                     | 5,567                      | 59,365                    | 0.152                     |
| CONVERTERS         | 54,369                     | 535,495                   | 0.309                     | 57,088                     | 562,270                   | 0.309                     |
| TRANSFORMERS       | 777                        | 13,398                    | 0.123                     | 816                        | 14,440                    | 0.127                     |
| CIRCUIT BREAKERS   | 78,131                     | 931,359                   | 2.663                     | 82,037                     | 984,127                   | 2.680                     |
| CONTROLLERS        | 304,687                    | 8,952,557                 | 4.809                     | 977,506                    | 10,875,717                | 5.563                     |
| GENERATORS         | 117,940                    | 762,592                   | 0.045                     | 160,877                    | 1,300,202                 | 0.073                     |
| MOTORS             | 257,506                    | 3,434,103                 | 0.224                     | 270,381                    | 3,646,356                 | 0.226                     |
| MOTOR GENERATORS   | 25,843                     | 106,835                   | 0.038                     | 27,136                     | 112,548                   | 0.038                     |
| RELAYS             | 15,233                     | 203,821                   | 1.944                     | 15,994                     | 216,409                   | 1.365                     |
| RHEOSTATS          | 2,082                      | 22,831                    | 0.214                     | 2,186                      | 24,221                    | 0.216                     |
| SWITCHES           | 103,217                    | 1,463,903                 | 1.229                     | 123,815                    | 1,779,916                 | 1.424                     |
| SWITCHBOARDS       | 62,632                     | 662,554                   | 0.101                     | 65,764                     | 698,699                   | 0.102                     |
| VISUAL ALARMS      | 6,000                      | 74,237                    | 0.774                     | 6,300                      | 78,692                    | 0.781                     |
| LIGHTING FIXTURES  | 9,960                      | 133,701                   | 3.523                     | 10,458                     | 142,040                   | 3.562                     |
| GYRO COMPASSES     | 44,151                     | 445,074                   | 0.295                     | 46,359                     | 467,327                   | 0.295                     |
| PROJECTION EQUIP   | 7,999                      | 90,057                    | 0.000                     | 8,399                      | 94,559                    | 0.000                     |
| I/C EQUIP          | 40,166                     | 430,132                   | 0.432                     | 42,174                     | 451,639                   | 0.432                     |
| NAVIGATIONAL EQUIP | 99,851                     | 1,113,673                 | 25.686                    | 125,395                    | 1,399,049                 | 30.732                    |
| INJECTORS          | 5,289                      | 49,042                    | 1.395                     | 5,554                      | 51,495                    | 1.395                     |
| BURNERS            | 20,805                     | 127,043                   | 0.254                     | 21,846                     | 133,395                   | 0.254                     |
| MARINE HARDWARE    | 17,718                     | 207,735                   | 0.301                     | 18,604                     | 219,775                   | 0.303                     |
| REFRIG EQUIP       | 254,757                    | 2,966,594                 | 0.286                     | 303,419                    | 3,566,188                 | 0.328                     |
| AIR CONDITIONING   | 20,301                     | 209,747                   | 0.927                     | 21,317                     | 221,309                   | 0.932                     |
| STARTERS           | 28,112                     | 257,218                   | 0.473                     | 29,517                     | 270,079                   | 0.473                     |
| WIPERS             | 4,412                      | 51,110                    | 14.753                    | 4,632                      | 53,914                    | 14.821                    |
| AUDIBLE ALARMS     | 9,866                      | 72,168                    | 0.390                     | 10,359                     | 76,190                    | 0.392                     |
| BEARINGS           | 15,287                     | 73,038                    | 0.025                     | 16,051                     | 77,269                    | 0.025                     |
| INDICATORS         | 84,675                     | 1,001,228                 | 1.086                     | 88,909                     | 1,057,944                 | 1.093                     |
| CLUTCHES           | 31,464                     | 134,936                   | 0.098                     | 33,037                     | 141,683                   | 0.098                     |
| FANS               | 11,463                     | 176,698                   | 0.101                     | 12,036                     | 189,335                   | 0.103                     |
| SHOP EQUIP         | 81,767                     | 997,708                   | 0.783                     | 130,703                    | 1,612,280                 | 1.205                     |
| REGULATORS         | 22,436                     | 240,302                   | 0.729                     | 23,558                     | 252,317                   | 0.729                     |
| GALLEY EQUIP       | 142,200                    | 1,599,478                 | 0.363                     | 149,319                    | 1,687,843                 | 0.365                     |
| DEHYDRATORS        | 27,981                     | 189,523                   | 0.146                     | 29,380                     | 198,999                   | 0.146                     |
| GAGES              | 34,801                     | 457,142                   | 0.338                     | 36,541                     | 485,373                   | 0.342                     |
| TESTING EQUIP      | 58,315                     | 633,337                   | 1.378                     | 61,231                     | 665,003                   | 1.378                     |
| FILTERS            | 104,360                    | 1,231,586                 | 0.569                     | 109,578                    | 1,301,350                 | 0.573                     |
| PANELS             | 141,138                    | 1,635,312                 | 0.630                     | 148,195                    | 1,726,336                 | 0.633                     |



Potential Inventory Increase

| Nomenclature           | 1988 Annual<br>Funds Avail | Total 1988<br>Funds Avail | 1988 Addnl<br>Parts/Range | 1989 Annual<br>Funds Avail | Total 1989<br>Funds Avail | 1989 Addnl<br>Parts/Range |
|------------------------|----------------------------|---------------------------|---------------------------|----------------------------|---------------------------|---------------------------|
| ISOLATORS              | 3,858                      | 8,533                     | 0.276                     | 4,050                      | 8,959                     | 0.276                     |
| HYDRALIC EQUIP         | 290,540                    | 2,946,147                 | 0.213                     | 360,385                    | 3,697,170                 | 0.254                     |
| CAPSTANS               | 25,974                     | 92,835                    | 0.076                     | 29,384                     | 121,950                   | 0.095                     |
| REELS                  | 25,743                     | 281,767                   | 1.271                     | 31,015                     | 343,730                   | 1.477                     |
| DAVITS                 | 12,674                     | 41,563                    | 0.048                     | 13,307                     | 43,807                    | 0.049                     |
| CRANES                 | 85,595                     | 358,159                   | 0.045                     | 89,875                     | 376,067                   | 0.045                     |
| HOISTS                 | 36,627                     | 385,531                   | 0.644                     | 38,458                     | 404,807                   | 0.644                     |
| ELEVATORS              | 21,239                     | 193,879                   | 0.130                     | 22,301                     | 203,573                   | 0.130                     |
| STEERING EQUIP         | 14,803                     | 166,846                   | 0.000                     | 15,543                     | 175,188                   | 0.000                     |
| CONTROL EQUIP          | 229,676                    | 2,654,892                 | 1.262                     | 241,160                    | 2,801,649                 | 1.268                     |
| WINCHES                | 109,420                    | 1,029,386                 | 0.156                     | 131,148                    | 1,264,442                 | 0.182                     |
| WINDLASSES             | 23,700                     | 114,159                   | 0.107                     | 24,885                     | 119,867                   | 0.107                     |
| FIREFIGHTING EQUIP     | 61,335                     | 657,417                   | 2.244                     | 64,401                     | 690,288                   | 2.244                     |
| LUBRICATORS            | 8,157                      | 89,398                    | 0.998                     | 8,565                      | 94,446                    | 1.004                     |
| ENGINES                | 1,001,362                  | 10,680,220                | 1.051                     | 1,051,430                  | 11,214,231                | 1.051                     |
| PLUMBING EQUIP         | 4,675                      | 57,411                    | 0.000                     | 4,908                      | 60,695                    | 0.000                     |
| GEARS AND REDUCERS     | 105,398                    | 904,660                   | 0.056                     | 110,668                    | 949,893                   | 0.056                     |
| GOVERNORS              | 218,161                    | 2,341,397                 | 1.789                     | 270,083                    | 2,912,805                 | 2.120                     |
| IGNITION EQUIP         | 2,297                      | 5,412                     | 1.472                     | 2,412                      | 5,683                     | 1.472                     |
| EJECTORS               | 11,595                     | 60,753                    | 0.048                     | 12,175                     | 63,998                    | 0.048                     |
| EDUCTORS               | 2,854                      | 17,933                    | 0.057                     | 3,164                      | 22,201                    | 0.067                     |
| STRAINERS              | 16,746                     | 259,007                   | 2.105                     | 17,584                     | 276,380                   | 2.140                     |
| PURIFIERS              | 141,363                    | 1,444,305                 | 0.938                     | 148,431                    | 1,516,521                 | 0.938                     |
| TRAPS-STEAM            | 3,159                      | 42,659                    | 0.420                     | 3,317                      | 45,371                    | 0.425                     |
| COUPLINGS              | 29,636                     | 280,060                   | 0.064                     | 34,449                     | 345,623                   | 0.075                     |
| SILENCING EQUIP        | 1,635                      | 18,787                    | 0.536                     | 1,717                      | 20,016                    | 0.544                     |
| BRAKES                 | 14,157                     | 169,031                   | 0.370                     | 14,864                     | 179,177                   | 0.374                     |
| BLOWERS                | 29,336                     | 268,264                   | 0.435                     | 30,803                     | 281,677                   | 0.435                     |
| WELDING SYSTEMS        | 37,501                     | 413,975                   | 0.000                     | 39,376                     | 434,674                   | 0.000                     |
| BOAT PROPULSION        | 41,762                     | 184,432                   | 0.016                     | 43,850                     | 194,729                   | 0.016                     |
| DECK MACHINERY         | 30,232                     | 330,048                   | 0.177                     | 31,744                     | 348,534                   | 0.178                     |
| PHOTOGRAPHIC EQUIP     | 1,870                      | 22,667                    | 0.000                     | 1,963                      | 23,925                    | 0.000                     |
| UNDERWATER LOG EQUIP   | 8,037                      | 45,489                    | 0.112                     | 8,439                      | 47,763                    | 0.112                     |
| VALVES                 | 613,455                    | 7,942,954                 | 2.334                     | 644,128                    | 8,421,447                 | 2.357                     |
| MISC PARTS             | 755,395                    | 8,400,231                 | 10.870                    | 793,165                    | 8,820,243                 | 10.870                    |
| LAUNDRY EQUIP          | 402,518                    | 4,480,568                 | 4.545                     | 505,353                    | 5,633,421                 | 5.443                     |
| TANKS                  | 35,912                     | 141,061                   | 0.015                     | 37,707                     | 149,065                   | 0.016                     |
| PIPE, HOSE, & FITTINGS | 5,520                      | 22,007                    | 0.084                     | 5,796                      | 23,272                    | 0.085                     |
| ASW EQUIP              | 35,572                     | 317,056                   | 1.322                     | 37,351                     | 332,909                   | 1.322                     |
| YELLOW GEAR            | 626,920                    | 7,485,028                 | 0.000                     | 658,266                    | 7,909,169                 | 0.000                     |
| PERISCOPES             | 16,476                     | 127,433                   | 0.143                     | 17,300                     | 133,804                   | 0.143                     |
| MISC EQUIP             | 19,468                     | 243,783                   | 1.806                     | 20,441                     | 258,163                   | 1.821                     |
| GRAND TOTALS           | 9,090,070                  | 98,080,683                |                           | 10,043,855                 | 109,018,840               |                           |
| Ave Depth Inc          | 0.017                      | 0.180                     |                           | 0.018                      | 0.190                     |                           |
| Ave # Parts            | 9.677                      | 104,414                   |                           | 10,183                     | 110,532                   |                           |

## APPENDIX K : TECHNICAL DATA MODEL<sup>123</sup>

NSLC developed an approach to objectively determine the value, to the government, of purchasing technical data. The following model provides a method for economically assessing the feasibility of acquiring data.

System Life (SL). System life, as the name implies, is the equipment's life expectancy. Part life (PL) is the part's equivalence to SL.

Replacement Rate (R). The replacement rate is the ratio of system life (SL) expectancy to part life expectancy (PL). The formula is:

$$R = (SL)/(PL)$$

Population (POP). The population includes all installed and replacement quantities, and is a function of the Replacement Rate (R) and Life Expectancy (L). Therefore:

$$POP = f(R, L)$$

Interest Rate (IR). Interest Rate is the standard government planning figure of 10%, therefore:

$$IR = 0.10$$

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<sup>123</sup> Unless other noted, this section was taken from Mr. Richard Jones' paper, H,M&E Standardization.

Unit Price (UP). The price per item is a function of the time value of money with the current price and interest rate (IR) as the baseline. The function is:

$$UP = f(IR)$$

Savings from Competition (SC). DAR Supplement 6 states that the government realizes a 25% savings from competition, so:

$$SC = 0.25$$

Obsolescence (O). Obsolescence is a factor that ranges from 0.0 to 1.0, and is developed from the following formula:

$$O = \frac{\text{Number of Years for Part Obsolescence}}{SL}$$

The default value = 1.0.

Testing and Tools (T). Testing and tools are the variable dollar costs for the total investment for special test equipment, tools, and other related costs.

Technological State of the Art (SA). This element is a measure of sensitivity to the stability to the industry. It directly reflects the technological currency of the equipment and ranges between 0.0 and 1.0. When there are fewer suppliers for outdated equipment, there is a greater stability risk, and the value will be closer to zero. As SA is related to the number of manufacturers within the industry (B), it can be measured as:

$$SA = 1 - 1/B$$

The default value is set to 1.0 since procurements are assumed to reflect current technology and are therefore low risk.

Potential for Commercial Applications (CA). CA reflects equipment applications within the civilian sector. Assigned a value between 0.0 and 1.0, a number close to 0 indicates that the equipment is common and readily available. The lower the percentage, the higher the potential for competition. The value of data ownership decreases with commonalty. CA is assumed to be inversely related to the number of APL's (Z) (i.e. substitutability). The formula is:

$$CA = 1/Z.$$

Model Formulation. Since the model computes the savings accrued through data ownership, the number of parts purchased following delivery of technical data must be computed. Part population over the lifetime, ( $POP_P$ ), equals the added parts installed following initial procurement, ( $POP_A$ ), and the replacement parts purchased to support all installed equipment, ( $POP_R$ ). It is assumed that following initial deliveries, procurements will be competitive and therefore the need to include  $POP_A$ . The formula is:

$$POP_P = POP_A + POP_R$$

$POP_A$  is computed from the formula:

$$POP_A = \sum_{y=1}^n X_y$$

where  $y$  denotes succeeding years, and

$X_y$  is the quantity that will be added to the population each year.

POP<sub>R</sub> is computed as:

$$POP_R = \left[ \sum_{y=0}^{\infty} X_{i+y} \right] (R)$$

where  $i$  denotes initial (as in initial procurement), and  $X_{i+y}$  includes all equipment, both initial procurements and follow-ons.

Since part life (PL) is the reciprocal of the part replacement rate, or:

$$PL = 1/R$$

Since  $1/R$  equals Best Replacement Factor (BRF), then BRF is substituted in the equation for PL.

POP<sub>R</sub> can then be restated as:

$$POP_R = \left[ \sum_{y=0}^{\infty} X_{i+y} \right] (BRF)(SL)$$

The price of the part in any year following first deliveries ( $P_y$ ) is a function of the initial Unit Price ( $UP_i$ ) and the interest rate (IR). The price for the part then becomes:

$$P_y = UP_i (1 + IR)^y$$

With this background, the formula for computing the potential savings is:

$$\left[ \sum_{y=1}^{\infty} X_y + \sum_{y=0}^{\infty} X_{i+y} (BRF)(SL) \right] [UP_i (1 + IR)^y] (.25)(O)(1-1/B)(1/Z) - T$$

If the price of the technical data package is less than the savings computed from the formula, then it is cost-effective to purchase the data rights.

The same formula can also be used as follows, to compute the value for a piece of equipment since it is really the sum of its  $m$  component parts:

$$\sum_{i=1}^m \{ [\sum_{y=1}^{\infty} X_y + \sum_{y=0}^{\infty} X_{i+y} (BRF)(SL) [UP_i (1 + IR)^y] ] (.25)(O)(1-1/B)(1/Z) - \sum_{j=1}^m T_j \}.$$

The only difference between the two formulas is that the latter uses  $\{ [\sum_{y=1}^{\infty} X_y + \sum_{y=0}^{\infty} X_{i+y} (BRF)(SL) [UP_i (1 + IR)^y] ]$  to compute the sum of the parts before applying the remainder of the equation.

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